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ASSESSING THE VIABILITY OF A NEW ZINC OR ZINC-LEAD SMELTER IN NEW BRUNSWICK

Précis Exécutif

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Introduction

Ce rapport vise à prévoir le besoin de la capacité nouvelle aux fonderies de zinc jusqu'à l'an 2000, ensuite à déterminer selon la logistique où cette capacité probablement serait construite et finalement d'examiner les économiques à la fois des fonderies neuves et des fonderies actuelles. On a surtout égard à la viabilité d'une fonderie neuve au Nouveau-Brunswick.

Conclusions

De la logistique, le marché zinc de l'Amérique du Nord ne fonctionne pas d'une efficacité maximale. La région exporte des concentrés de zinc du Canada et du Mexique - et importe le zinc aux États-Unis. La plupart du zinc importé aux États-Unis venant dehors de l'Amérique du Nord vient de l'Europe, tandis que beaucoup du zinc produit en Europe se base sur des concentrés importés ou du Canada ou du Mexique. De la logistique, it serait mieux si les fonderies nord-américaines traiteraient davantage des concentrés nords-américains afin de déplacer les exports européens aux États-Unis. À en accomplir au cours du deuxième moitié de cette décennie il faudrait à peu près de 150.000 tonnes de la capacité nouvelle aux fonderies nord-américaines.

Cette nouvelle capacité viendrait des expansions marginales aux fonderies ou de la construction d'une fonderie neuve. Notre analyse démontre que les expansions marginales sont moins coûtuese que des fonderies neuves. Les calculs du coût et du révenu démontre que des expansions marginales des fonderies Valleyfield au Quebec, Trail en Colombie-Britannique et Torreon en Mexique seraient viable du point de vue économique.

Une fonderie neuve au Nouveau-Brunswick a été soumis à l'analyse du coût et du revenue en quatre scénarios des technologies divers. Les quatre méthodes sont l'électrolytique, Imperial Smelting Furnace (ISF), Sherritt Gordon Pressure Leaching (SGPL) et Ferric Chloride Leaching (FCL). L'électrolytique ne peut utiliser que des concentrés de zinc. L'ISF and la SGPL peuvent utiliser des mélanges des concentrés de zinc et de plomb aussi bien que des concentrés de zinc. La FCL ne peut fonctionner qu'avec les concentrés an vrac.

L'abilité de traiter les concentrés en vrac serait très importante pour une fonderie au Nouveau-Brunswick. Les concentrés en vrac qui sont actuellement produits au Nouveau-Brunswick ne peuvent pas être affinés au Canada et sont exportés à l'Europe. En plus, une des raisons que le mine Caribou s'était fermé est que ses concentrés en vrac étaient très difficile à traiter donnant la technologie de la fonte actuelle.

Un danger possible au temps lointain pour une fonderie qui ce base sur la traitment des concentrés en vrac de zinc et de plomb est que les règlements du l'environnement pourraient faire illégal l'utilisation du plomb dans plusieurs, si non tout, produits. Nous doutons vraiment que cela viendrait au moins qu'une alternative viable à la battérie au plomb, tant économique que téchnologique ne soit développée. Beaucoup de recherche se fait depuis des années pour en développer. Néanmoins, bien qu'une telle système de battérie nouvelle pourrait être développée, il prendrait plus qu'une décennie avant que cette technologie ne soit instituée dans toute l'industrie automobile mondiale.

L'analyse du coût et du révenu des fonderies neuves au Nouveau-Brunswick a compris une considération des bénéfices des impôts qu'une fonderie de concentrés à la province s'en servirait. Avec ses bénéfices compris les fonderies ISF, SGPL et PCL obtiendraient des bénéfices desirées de l'ordre de 20 pour cent de l'investissement. Une fonderie électrolytique ne pourrait pas le faire.

Centrale à déterminer la possibilité des fonderies ISF, SGPL et FCL est la technologie. Il y a des années, Brunswick Mining ne pourrait pas obtenir les résultats des opérations satisfaisant avec une fonderie ISF et ils l'ont converti en fonderie de plomb. Aussi on doit déterminer si les avances technologiques des fonderies ISF depuis lors permettraient le traitement réussi des concentrés en vrac de Nouveau-Brunswick. En ce moment, ses concentrés fondés en Europe doivent être mélangés avec d'autres concentrés afin d'achever une charge convenable à la fonte.

La mèthode SGPL s'emploie actuellement conjointement avec la fonte électrolytique à Trail and Kidd Creek au Canada et à Datteln en Allemagne. On est en train de l'installer à Flin Flon afin de traiter les concentrés de zinc. La méthode n'a pas été appliquée à une fonderie toute seule qui ne traite que des concentrés en vrac et de zinc tel qu'on le ferait au Nouveau-Brunswick. Sherritt Gordon est confiant qu'une telle opération ne presenterait pas des problèmes techniques.

COMPARAISON DES FONDERIES AU NOUVEAU-BRUNSWICK EN 1995

($/tonne metal)

	Électrolytique	ISF	SGPL	FCL
RÉVENU				
Taux Du Traitement + Zinc Non-Payé	718	929	858	1303
Prime En Sus Du Taux	28	28	28	28
Prime Du Métal	132	132	132	132
Revenu total:	878	1089	1018	1463
COÛT - DÉPENSES				
Coût En Capital Annuel	651	482	599	421
Frais Généraux	19	31	19	19
Frais Nets D'Operation	460	600	487	401
Coût Total:	1130	1113	1105	841
RÉVENU				
Révenu Total	878	1089	1018	1463
Moins Coût Total	-1130	-1113	-1105	-841
Révenu Net:	(252)	(24)	(87)	622
EFFET DES IMPÔTS	123	91	113	79
Révénu Ajusté:	(129)	67	26	701

La méthode FCL a donné la meilleure balance entre le coût et le revenu mais la technologie n'est pas prouvé et alors il se pourrait que les calculs des coûts soient trop bons.

Si la capacité nouvelle de la fonderie de zinc que le marché nord-américain pourait soutenir doit venir d'une fonderie neuve au Nouveau-Brunswick, il faut que le planning commence bientôt. Quand le marché se rélève de la récession actuelle et quand les profits de l'industrie s'améliorent, nous nous attendons que les fonderies recommenceraient des expansions marginales. In n'y a qu'un total fini de la capacité nouvelle que le marché nord-américaine soutiendrait et cette capacité pourrait être remplie par des expansions marginales.

Actuellement, la fonderie à Torreon en Mexique est en train de s'expander, comme résultat qu'une deuxième expansion ne soit que peu possible à l'avenir proche. Il n'est pas probable que Cominco considererait de nouveau une expansion à Trail avant qu'ils n'aient résolver les problèmes associés avec leur fonderie de plomb nouvelle ou quand leur condition financière s'ameliorerait. On n'est pas sûr s'il existe des concentrés locaux pour faire une expansion a Trail. Le mine Sullivan fermera avant l'an 2000. Une expansion d'une fonderie pourrait entrainer une expansion du grand mine Red Dog du Cominco en Alaska.

Pour plusieurs raisons, la fonderie Valleyfield de Noranda semble être le candidat le plus possible pour l'expansion. Néanmoins, Noranda a maintes projets qui poursuivent les fonds disponibles pour l'argent et en ce moment la société n'a pas trouvé l'expansion de Valleyfield un investissement trop engageant. Nous comprenons que le projet sera étudié encore une fois quand les conditions du marché s'améliorerait.

Alors, nous recommendons que:

1. On ce met en contact avec Imperial Smelting afin de voir si la technologie ISF serait convenable au traitement des concentrés en vrac de Nouveau-Brunswick.

2. On obtient une évaluation impartiale experte des possibilités de la réalisation commerciale de la méthode FCL et combien de temps il faudrait pour prouver la technologie.

3. On détermine lesquelles des trois méthodes -- ISF, SGPL ou FCL -- va mieux avec le traitement des concentrés en vrac de Nouveau-Brunswick aussi bien que lesquelles s'incorporerait dans une fonderie commerciale pendant que ce soit possible.

Ce rapport se présente en cinq chapitres. Le précis suit.

Besoin de la Capacite Nouvelle

Les calculs étaient développés du marché de zinc jusqu'à l'an 2000. On s'attends à ce que l'usage s'accroîtrait au taux moyen de 2,1 pour cent chaque année au cours de la décennie. Les calculs étaient aussi faits pour la production minière et secondaire, pour le commerce des concentrés des pays de l'Est et de l'Ouest et des métaux aussi bien que pour la production primaire d'une fonderie.

Ce chiffre de production primaire était ensuite comparé à la capacité primaire qu'on compte sur être disponible en 1994. De ces données nous avons ensuite calculé combien de capacité nouvelle devrait être ajouter pendant la période 1995-2000 afin de satisfaire les demandes du marché.

Puis, nous avons calculé les soldes des marchés régionaux les plus vraisemblables. À en faire, il fallait deviner où la production nouvelle des mines se développerait au cours des années 1995-2000. De là, nous avons déterminé la demande régionale, nous avons deviné la production des mines et finalement nous avons ajouter la capacité des fonderies par région.

Il faut ajouter près de 750.000 tonnes/an de la capacité nouvelle aux fonderies non-socialiste pendant la période 1995-2000 afin de servir le besoin prévu pour le zinc et de traiter le niveau prévu de la production du zinc concentré. L'augmentation la plus grande dans la demande du zinc et dans la production de zinc aurait lieu en Australasie. Alors, on s'attendrait que près de 400.000 tonnes/an de la capacité nouvelle seront construites en Australasie. L'Amérique du Nord, le Mexique y compris, soutiendrait presque 150.000 tonnes/an de la capacité nouvelle, pendant que l'Amérique du Sud ajouterait 200.000 tonnes/an. Actuellement, l'Europe importe des concentrés et exporte le métal. Elle a de la capacité suffisante à soutenir l'augmentation de la demand regionale jusqu'à l'an 2000, mais elle n'en a pas assez de soutenir aussi bien le niveau actuel des exportations. Le commerce d'exportation de l'Amérique du Nord se perdrait à revers de la production augmentée aux fonderies nord-américaines.

Frais de la Capacite Nouvelle

Afin d'évaluer les frais de la capacité nouvelle, RSI a simulé la construction de huit fonderies neuves et de neuf expansions marginales. Les fonderies neuves sont électrolytiques et se trouvent au Nouveau-Brunswick, en France, à l'Indonésie, en Queensland et en Japon, et les fonderies d'Imperial Smelting Furnace (ISF) au Nouveau-Brunswick, en Thaïlande et en Japaon. Les expansions marginales sont les fonderies électrolytiques au Canada (Valleyfield et Trail), en Mexique (Torreon), en Australie (Risdon), en Coreé (Onsan), en Japon (Iijima), en Espagne (Asturiana), au Brésil (Juiz de Fora) et en Pérou (Cajamarquilla). Les coûts étaient calculés en dollars américains de 1995.

Si on compare les frais bruts d'exploitation des fonderies neuves (le capital plus les frais d'exploitation y compris), on voit que l'Indonésie a les frais les plus bas. Ensuite on a le Queensland, la France, le Nouveau-Brunswick et le Japon. L'ISF la moins coûteuse se trouverait au Japon, puis au Nouveau-Brunswick et en Thaïlande. Des huit fonderies neuves l'ISF japonais a les frais d'exploitation les moins coûteux des fonderies neuves. Ces frais sont éstimés être $922 par tonne. L'Indonésie vient en seconde lieu avec $1.025 et le troisième est le Queensland avec $1.060. Il faut noter que la définition de RSI des frais d'exploitation comprend un ordre de bénéfices désirées de 20 pour cent de la partie actionnaire des frais d'établissements annuels. Alors, les frais bruts pour chaque fonderie représentent le révenu désiré qu'il faut pour justifier l'investissement.

Des neuf expansions marginales, les frais d'exploitation les plus bas seraient à Torreon. Valleyfield serait seconde, suivi de Onsan, Risdon, Austuriana, Trail, Juiz de Fora, Iijima, et Cajamarquilla. Les quatre plus bas - Torreon, Valleyfield, Onsan et Risdon - ont les frais totaux de moins de $800. Asturiana et Trail ont les coûts totaux qui sont moins de $900.

Alors, la fonderie neuve la moins coûteuse, l'ISF japonaise, aurait les coûts plus hauts que six des expansions marginales. Cette analyse soutient la thèse courante que les expansions marginales sont par inhérence plus économique que des capacités neuves.

Révenus des Fonderies

La source primarie des révenus des fonderies est le taux du traitement chargé pour fondre des concentrés. Ce taux diffère d'une région à l'autre à cause des logistiques. Une fonderie près d'un mine peut imposer un taux de traitement plus éléve qu'elle ne fasse à une fonderie plus lointain parce que le mine doit payer les frais du transport à la fonderie. Dan cette étude on appelle cela la prime locale du taux de traitement.

Les fonderies gagnent aussi du révenu en récupérant plus du zinc des concentrés qu'ils ne paient. Normalement une fonderie paye 85 pour cent du zinc continu et elle récupère 96 pour cent.

Une troisième source du révenu vient des métaux sous-produits, par example, le cadmium et le germanium. Aucun paiement ne soit fait au mine pour ces métaux de même pour la contenu sulfurique des concentrés. Aucun paiment ne soit fait pour le soufre tandis que la plupart des fonderies recupérènt et vendent le soufre comme l'acide sulfurique. Il y a des différences vastes entre le prix net que les fonderies reçoivent pour l'acide sulfurique, selon des prix courants régionaux et selon les frais due transport jusqu'aux consommateurs de l'acide.

Une source finale de la révenu des fonderies est la prime reçue en sus du prix de référence. Ce prix de référence vient du London Metal Exchange (LME). Presque tout le zinc vendu reçoit quelque prime en sus de LME. Le montant de la prime reçu varie avec le temps selon les conditions du marché et du pays en pays selon des tariffs d'importation et des conditions concurrentes.

Normalement, les fonderies européenes donnent la moyenne de 1,5 cents/livre dans leur prime du métal. Les Japonais reçoivent à peu près de 7 cents, les Coréens reçoivent de 8 en 9 cents et les Nord-Américains reçoivent près de 6 cents. La fonderie thaïlandaise reçoit actuellement la prime la plus haute. Cette fonderie a la protection d'un taux d'importation ad valorem.

La rangée des révenus des fonderies en 1995 pour ces 17 projets va d'un bas de $751/tonne pour les Français et les Espagnoles au haut de $1.194/tonne pour l'ISF thaï. Les trois fonderies ISF - en Japon, en Thaïlande et au Nouveau-Brunswick produiraient chacunes plus de $1.000/tonne en révenu.

Comparaison Du Cout Et Du Révenue Des Fonderies

Quand on compare les prévisions du coût total avec celles de révenu nous voyons qu'une seule fonderie neuve surpasserait la cible du taux des rémises. C'est l'ISF japonaise. L'ISF au Nouveaux-Brunswick ne manque que de $24/tonne et l'ISF thaïe que de $57/tonne. Parmi des fonderies neuves électrolytiques l'usine en Indonésie s'approche au mieux la cible. Elle ne manque que $145.

Des neuf expansions marginales, cinq obtiendraient ou surpasseraient leurs cibles du révenu. Les cinq seraient - Torreon, Onsan, Valleyfield, Risdon et Trail.

COMPARAISON DU RÉVENU NET DES FONDERIES EN 1995

(\$/tonne metal)

Fonderies Neuves	Coût Total	Révenu Total	Révenu Net
Électrolytique-Nouveau Brunswick	$1.130	$878,10	(251,90)
ISF-Nouveau Brunswick	1.113	1.089,13	(23,87)
Électrolytique-Japon	1,419	872,25	(546,25)
ISF-Japon	922	1.083,28	161,28
ISF-Thailande	1.251	1.193,53	(57,47)
Électrolytique-Queensland	1.060	865,89	(194,11)
Électrolytique-Indonésie	1.025	879,60	(145,40)
Électrolytique-France	1.108	750,98	(357,02)
Expansions Marginales			
Valleyfield	$775,15	$878,10	$102,95
Trail	835,97	865,37	29,40
Torreon	757,48	899,02	141,54
Risdon	798,04	870,74	72,70
Onsan	792,97	905,33	112,36
Iijima	951,89	872,25	(79,64)
Asturiana	829,48	750,98	(79,50)
Juiz de Fora	935,50	899,51	(35,99)
Cajamarquilla	1.133,99	901,01	(232,98)

Considerations Techniques Et Économiques Pour Une Fonderie Au Nouveau-Brunswick

Comme ci-noté une fonderie électrolytique de zinc conventionnelle au Nouveau-Brunswick aurait des coûts totaux bien plus hauts que son révenu estimé (252/tonne). Une fonderie ISF viendrait bien plus près au but ($24).

Néanmoins, une fonderie ISF peut-être ne marcherait pas en vue de la composition différente des concentrés en vrac au Nouveau-Brunswick. Brunswick Mining a essayé à exploiter une fonderie ISF il y a des années, mais n'avais pas achevé les résultats satisfaisants, et alors l'usine était converti en fonderie de plomb.

Deux autres méthodes à traiter les concentrés de Nouveau-Brunswick sont examineés. La première est le Sherritt Gordon Pressure Leaching (SGPL). La seconde est la méthode FCL de Canmet.

La méthode SGPL demande une combination du zinc et des concentrés en vrac pour son charge. Ce procédé elimine le grillage et, alors, il n'y a de SO_2 produit. Cela éliminerait le besoin pour un usine de l'acide sulfurique. On en capturait du soufre simple.

Nous calculons qu'une fonderie SGPL aurait un coût capital par tonne plus bas qu'une électrolytique mais un coût capital plus haut qu'une ISF. Ses coûts d'exploitation seraient plus haut que ceux d'une électrolytique mais plus bas qu'une ISF. Son coût total de $1.015 serait à peine plus bas que les deux autres méthodes. La comparaison du coût et du révenu démontre que la fonderie SGPL manquerait $87 pour achever un révenu de 20 pour cent sur les investissements.

La méthode FCL est surtout désigné à traiter les grades inférieures des concentrés en vrac tels qu'on produit au Nouveau-Brunswick. Nos calculs indiquent qu'une fonderie FCL aurait des coûts très concurrents. Le coût capital par tonne serait moins à une ISF et bien plus moins à une SGPL ou à une électrolytique. Les frais d'exploitation d'une fonderie FCL seraient moins que ceux des trois autres méthodes. Les frais totals ne seraient que $841/tonne.

Néanmoins, il faut souligner que la technologie FCL n'est pas prouvée. Il n'existe aucune installation duquelle on pourrait estimer les coûts.

Comme la SGPL, la FCL n'aura pas besoin d'un usine de l'acide. Aussi, elle produirait du soufre.

La FCL aurait un révenu de $1.463/tonne du zinc qui rendant un résultat positif de $622 en plus du 20 pour cent en sus de la cible visé sur les investissements. La grande incertitude avec la FCL est si on pourrait achever les coûts qu'on met dans ces estimations.

On a aussi examiné l'effet d'une fonderie FCL sur les révenus du mine qui fournirait des concentrés en vrac. La comparaison pour cette estimation serait entre un mine qui produirait à la fois du zinc, du plomb, du cuivre, et des concentrés an vrac, et un mine qui ne produirait au'un seul concentré en vrac. Le dernière perdrait du révenu s'il ne produirait qu'un seul concentré en vrac mais la combination des révenus du mine et de la fonderie surpasserait les révenus d'un mine qui produirait et vendrait des concentrés divers.

Une fonderie neuve au Nouveau-Brunswick pourrait avoir des règlements de l'environnement de plus en plus rigoreux au sujet de la disposition des résidus de fer. Ces résidus sont le résultat du lessivage des oxydes de zinc afin d'augmenter la récuperation métallurgique du zinc. La pratique courante est d'utiliser des bassins de rétenue. La technologie la plus courante, le procès jarosite, est bien moin constante et elle produit plus de résidue que les autres méthodes tel que l'hematite ou le fer oligiste. Un usine nouveau pourrait facilement utiliser ces deux dernières méthodes.

Le direction de la technologie va vers le traitement des residus de fer afin de récupérer le contenu ferrique. On en risque l'augmentation du capital et des frais d'exploitation parmi la plupart des usines en gestion et parmi les fonderies neuves aux pays industrialisés.

Finalement, nous avons examiné les effets des impôts selon les lois du Nouveau-Brunswick. Ces lois se visent à attirer encore le traitement des minéraux à la province. Les crédits pour les coûts capitals vis-à-vis l'impôt net sur le révenu et vis-à-vis l'impôt des bénéficies net vaudraient beaucoup - à l'ordre de $79/tonne du zinc produit à la FCL jusqu'à $91/tonne à l'ISF et $113/tonne à la SGPL.

Ces crédits compenseraient bien les manques des fonderies ISF et SGPL. Cela rendrait la FCL bien plus profitable.

GLOSSAIRE

Production primaire du zinc. Le zinc produit de rendement des mines tel que les minérais.

Production secondaire du zinc. Le zinc produit du rendement des déchets qui contiennent du zinc.

Fonderie neuve. Une fonderie tout à fait nouvelle qui soit construit à l'emplacement nouveau. Le coût d'en construire comprend le dévelopment de l'infrastructure nécessaire.

Expansion marginale. Le dévelopment de la capacité supplémentaire à une fonderie en gestion par moyen d'ajouter ou la machinérie ou l'équipement.

Concentrés de zinc. Le produit intermédiaire entre le minérai zincifère et le zinc. Le minérai est broyé ou concentré afin d'éléver le contenu du zinc au niveau acceptable à fonder. Normalement le minérai contiendrait de 5 en 15 pour cent du zinc pendant que le concentré serait à l'ordre de 50 en 55 pour cent.

Concentrés en vrac. Un concentré qui contient du zinc et du plomb récupérable. Ce n'est pas une matière primaire acceptable pour une fonderie électrolytique de zinc. Imperial Smelting Furnace s'était developpée à traiter des concentrés en vrac. La plupart des mines produit soit un concentré de zinc soit des concentrés de zinc et de plomb.

Pourtant, quelques minérais ne peuvent pas être totalement séparés et une partie du métal contenu - et de fois tout - doit être récupéré comme concentré en vrac.

Fonderie électrolytique du zinc. La technologie la plus courante pour fondre le zinc, elle comprend une méthode de trois étages c'est-à-dire le grillage, le lessivage et l'électrolyse. Cette méthode ne marche que pour des concentrés de zinc. L'anhydride sulfureux est déchargé au cours du grillage. Dans la plupart des pays les règlements de l'environnement exigent que ce gaz soit retenu et non pas déchargé dans l'atomosphère. Normalement le gaz retenu est transformé en l'acide sulfurique.

Imperial Smelting Furnace (ISF). Une technologie développée pour la fonte simultanée du zinc et du plomb. Pour la plupart la charge du concentré est un mélange des concentrés de zinc et des concentrés en vrac de zinc et de plomb. Le zinc est récupéré en forme vendable, mais le plomb est récupéré comme lingot qui ensuite doit être affiné. Les métaux précieux contenus dans la charge du concentré normalement s'attachent aux lingots de plomb et sont récupérés au cours de l'affinage.

Sherritt Gordon Pressure Leaching (SGPL). Une méthode de la fonte ou des concentrés sont lessivés à haute pression au lieu d'etre griller. Cette méthode est convenable au traitement soit des concentrés de zinc soit des mélanges de zinc et des concentrés en vrac. Puisque le grillage est éliminé, aucun anhydride sulfureux ne soit produit. Le contenu sulfurique des concentrés est récupéré comme soufre simple. Le plomb est récupéré comme résidu qui ensuite doit être affiné à une fonderie de plomb.

Ferric Chloride Leach (FCL). Une méthode de la fonte développée par Canmet pour le traitement des concentrés en vrac inférieurs. Il n'y faut aucun mélange des concentrés de zinc. Comme avec la SGPL, aucun anahydride dioxyde sulfureux n'en soit produit et le soufre est récupéré comme soufre simple. C'est la seule méthode par laquelle le contenu du plomb des concentrés en vrac soit récupéré en forme vendable, c'est à dire qu'il ne faut pas faire encrore d'affinage. Cette méthode est toujours en traine d'être développée et on ne l'a pas mis au preuve dans une installation pilote.

Capacité effective d'une fonderie primaire. La production maximum qu'une fonderie a realisé au cours d'une année. Plaque de la capacité est le niveau maximum de production en théorie.

Taux de traitement. Le montant soustrait de la valeur brute du concentré afin de payer les frais de la fonte. Le mineur est payé selon le pourcentage du zinc dans le concentré - normalement 85 pour cent - moins le taux de traitement. Aux contrats pour acheter des concentrés le taux de traitement s'est exprimé en dollars/tonne de concentré. Le taux de traitement est declaré avec un prix de reférénce pour le zinc en forme metallique. Au moment que le prix courant soit en sus ou en bas du prix de réference, le taux de traitement s'accoît ou décroît selon une formule fixée.

Frais net d'exploitation. Les frais directs qu'une fonderie a au cours du traitement d'une tonne du métal. Le remboursement soit des fonds socials soit des frais généraux n'y sont compris. La valeur des sous-produits récupérés soit métal soit soufre au cours de la fonte est soustraite avant le calcul des frais nets d'exploitation.

Frais bruts d'exploitation. Les frais nets d'exploitation plus les frais généraux plus le remboursement des fonds socials. Selon la méthodologie de RSI les fonds socials comprennent le taux visé de révenu sur la partie des investissements capitaux. De trouver les frais capitaux annuelle, il faut prendre le London Inter Bank Offering Rate (LIBOR) plus 3 pour cent. Le financement se fait deux tiers du LIBOR et un tiers des fonds socials, le tout donnant un révenu du 20 pour cent.

LIBOR. London Inter Bank Offering Rate. La mésure disponible la plus courante pour les taus d'intérêt disponibles pour les sociétés à emprunter. Les sociétés bien établies et solides en matières de finance peuvent emprunter à LIBOR. Les sociétés moins bien établies normalement doivent payer une prime en sus du LIBOR.

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ASSESSING THE VIABILITY OF A NEW ZINC OR ZINC-LEAD SMELTER IN NEW BRUNSWICK

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EXECUTIVE SUMMARY

Introduction

The purpose of this study is to project the need for new zinc smelter capacity to the year 2000, to determine from a logistical standpoint where new capacity would most likely be built and then to examine the economics of new smelter capacity -- both from new greenfield smelters and from incremental expansions of existing smelters. Particular attention is paid to the viability of a greenfield smelter in New Brunswick.

Conclusions

From a logistical standpoint the North American zinc market does not presently function with maximum efficiency. The region is an exporter of zinc concentrates -- from Canada and Mexico -- and an importer of zinc metal -- to the U.S. Most of the zinc metal imported into the U.S. from outside of North America is produced in Europe, while much of the zinc produced in Europe is based on concentrates imported from Canada and Mexico. Logistically, it would be more logical for North American smelters to process more North American concentrates so as to displace European exports to the U.S. To achieve this over the second half of this decade, approximately 150,000 tonnes of new North American smelter capacity would be needed.

This new capacity could come from incremental expansions of existing smelters or from the construction of a new greenfield smelter. Our analysis shows that incremental expansions are less costly than greenfield smelters. Cost/revenue calculations show that incremental expansions of the Valleyfield smelter in Quebec, the Trail smelter in British Columbia and the Torreon smelter in Mexico would be economically viable.

A greenfield smelter in New Brunswick was also subjected to cost/revenue analysis under four different technology scenarios. The four technologies are electrolytic, Imperial Smelting Furnace (ISF), Sherritt Gordon Pressure Leaching (SGPL) and Ferric Chloride Leaching (FCL). The electrolytic process could treat only zinc concentrates. The ISF and SGPL processes could treat a combination of bulk zinc/lead concentrates as well as zinc concentrates. The FCL process would be able to function on bulk concentrates alone.

The ability to treat bulk concentrates would be very important for a New Brunswick smelter. The bulk concentrates currently produced in New Brunswick cannot be processed in Canada and are exported to Europe. Furthermore, one of the reasons the Caribou mine was forced to close was that its bulk concentrates were very difficult to process using currently available smelter technology.

A long-term potential danger for a smelter based on the treatment of bulk zinc-lead concentrates is that environmental pressures could outlaw the use of lead in some, if not all, products. We seriously doubt that this would happen unless, and until, an economically and technologically viable alternative to the automobile lead-acid battery is developed. Considerable research has been underway for many years to develop a technologically and economically viable alternative to the lead acid battery. Even if such a new battery system could be developed it would take more than a decade for any alternative technology to be implemented throughout the world auto industry.

The cost/revenue analysis for the New Brunswick greenfield smelters included consideration of the tax benefits available to a smelter treating concentrates in the Province. With the inclusion of these tax benefits the ISF, SGPL and FCL smelters could achieve a target rate of return of 20 percent on the equity investment. An electrolytic smelter could not.

A key issue for determining the feasibility of ISF, SGPL and FCL smelters is technological. Some years ago Brunswick Mining was unable to achieve satisfactory results operating an ISF smelter and converted the plant to a lead smelter. An area for further investigation is to determine whether technological advancements in ISF smelting over the intervening years would permit the successful processing of New Brunswick bulk concentrates. Presently, New Brunswick bulk concentrates smelted in Europe must be blended with other concentrates to achieve a feed suitable for smelting.

The SGPL process is being used at present in conjunction with electrolytic smelting at Trail and Kidd Creek in Canada and at Datteln in Germany. It is being installed at Flin Flon to treat zinc concentrates. The process has not been applied to a stand-alone smelter treating bulk and zinc concentrates, such as would be the case in New Brunswick. Sherritt Gordon expressed confidence that such an operation would not present a technological problem.

1995 NEW BRUNSWICK SMELTER COMPARISON
($/tonne metal)

	Electrolytic	ISF	SGPL	FCL
REVENUE				
Base Treatment Charge + Unpaid Zinc	718	929	858	1303
TC Premium	28	28	28	28
Metal Premium	132	132	132	132
Total Revenue:	878	1089	1018	1463
COST				
Annualized Capital Cost	651	482	599	421
Corporate Charge	19	31	19	19
Net Operating Cost	460	600	487	401
Full Cost:	1130	1113	1105	841
BALANCE				
Total Revenue	878	1089	1018	1463
Less Full Cost	-1130	-1113	-1105	-841
Net Balance:	(252)	(24)	(87)	622
TAX SAVING	123	91	113	79
Adjusted Balance:	(129)	67	26	701

The FCL process produced the best cost/revenue balance, but the technology is unproven and hence the cost estimates could be overly optimistic.

If the new zinc smelter capacity that the North American market could support is to come from a New Brunswick greenfield smelter it is important that planning should commence fairly soon. Once the market recovers from the current recession and industry profitability improves, we would expect that smelters will again consider incremental expansions. There is only a finite amount of new capacity that the North American market could support and this could be preempted by incremental expansions.

At present, the Torreon smelter in Mexico is undergoing an expansion, so that consideration of another expansion would be unlikely for at least a few more years. Cominco is unlikely to reconsider a Trail expansion until it solves the problems associated with its new lead smelter and until its financial position improves. There is some uncertainty as to available local or nearby concentrates for a Trail expansion. The Sullivan mine will close by 2000. A smelter expansion might necessitate an expansion of Cominco's giant Red Dog mine in Alaska.

In many ways Noranda's Valleyfield smelter seems the most logical candidate for expansion. However, Noranda has many projects vying for available funds and to date the company has not found a Valleyfield expansion a particularly attractive investment opportunity. We understand that the project will again be studied when market conditions improve.

Thus, we would recommend that:

1. Contact be established with Imperial Smelting personnel to see if ISF technology would be suitable to treat New Brunswick bulk concentrates.

2. Secure an impartial expert evaluation of the prospects for commercial realization of the FCL process and the time that would be needed to prove out the technology.

3. Determine which of the three process -- ISF, SGPL or FCL -- would be best suited to processing New Brunswick bulk concentrates and which could be incorporated in a commercial smelter while the window of opportunity is still open.

This study is presented in five chapters which are summarized below:

Need For New Capacity

Projections were developed for the zinc market through 2000. Consumption is projected to grow at an annual average rate of 2.1 percent over the decade. Forecasts were also developed for mine and secondary production, East/West trade in concentrates and metal and primary smelter production.

This primary smelter production figure was then compared with effective primary capacity scheduled to be onstream in 1994.

From these two sets of numbers we then calculated the amount of new smelter capacity that would have to be added over the 1995-2000 period in order to satisfy market demand.

Next, we estimated what would be the most likely regional market balances through 2000. To do this we had to estimate where the new mine production in the 1995-2000 period would be developed. From this we determined regional demand and mine production estimates and incorporated 1994 smelter capacity for each region.

Approximately 750,000 tpy of new smelter capacity will have to be added in the non-socialist world over the 1995-2000 period to meet the projected need for zinc and to treat the projected level of zinc concentrate production. The greatest growth in zinc demand and zinc mine production is expected to occur in Australasia. Thus, from a logistical standpoint we could expect that about 400,000 tpy of new smelter capacity could be built in Australasia. North America, including Mexico, could sustain about 150,000 tpy of new smelter capacity, while South America could add 200,000 tpy. Europe currently imports concentrates and exports metal. It has adequate smelter capacity to support growth in domestic demand through 2000, but not enough to also support its current level of exports. The North American export market could be lost to increased North American smelter production.

Cost of New Capacity

To assess the cost of new smelter capacity, RSI simulated the construction of eight greenfield projects and nine incremental expansions. The greenfield projects are electrolytic smelters in New Brunswick, France, Indonesia, Queensland and Japan, and Imperial Smelting Furnace (ISF) smelters in New Brunswick, Thailand and Japan. The incremental expansions were electrolytic smelters in Canada (Valleyfield and Trail), Mexico (Torreon), Australia (Risdon), Korea (Onsan), Japan (Iijima), Spain (Asturiana), Brazil (Juiz de Fora) and Peru (Cajamarquilla). Costs were calculated in 1995 US dollars.

The full cost (capital plus operating costs) ranking of the greenfield electrolytic plants shows Indonesia as the lowest cost, followed by Queensland, France, New Brunswick and Japan. The lowest cost ISF would be Japan, followed by New Brunswick and Thailand. The Japanese ISF has the lowest full cost of the eight greenfield projects at $922/tonne. The second lowest is Indonesia at $1,025 and the third lowest is Queensland at $1,060. It should be noted that RSI's definition of full costs includes a target rate of return of 20 percent on the equity portion of the annualized capital cost. Thus, the full cost figures for each smelter represent a revenue target needed to justify the equity investment.

Of the nine incremental expansions costed, the lowest full cost of production would be at Torreon. Valleyfield would rank second, followed by Onsan, Risdon, Asturiana, Trail, Juiz de Fora, Iijima and Cajamarquilla. The four lowest cost expansions -- Torreon, Valleyfield, Onsan and Risdon -- have full costs of less than $800. Asturiana and Trail, have full costs less than $900.

Thus, the lowest cost greenfield project, the Japanese ISF, would have higher costs than six of the incremental expansions.

This analysis supports the widely-held contention that incremental expansion is inherently more economical than new greenfield capacity.

Smelter Revenues

The main source of smelter revenue is the treatment charge imposed to smelt concentrates. These charges will vary regionally for logistical reasons. A smelter located near a mine can impose a higher treatment charge on that mine than a more distant smelter because the mine must pay the cost of transportation to the smelter. This is referred to in this study as the treatment charge location premium.

Smelters also derive revenue by recovering more of the zinc contained in concentrates than they pay for. Typically, a smelter pays for 85 percent of the contained zinc and recovers 96 percent.

A third source of revenue is from by-product metals that are recovered by smelters, such as cadmium and germanium. No payment is made to the mine for these metals. The same applies to the sulfur content of the concentrate. No payment is made for sulfur, while most smelters recover sulfur as sulfuric acid and sell it. There are widespread differences in the net back price smelters receive for sulfuric acid, based on regional market prices and the transport cost to reach acid consumers.

A final source of smelter revenue is the premium it receives in its metal sales price over the reference price used to pay for the zinc contained in the concentrates. The concentrate buying reference price is the London Metal Exchange (LME). Almost all of the zinc sold commands some premium over the LME. The size of the premium smelters receive varies over time based on market conditions and from country-to-country based on import tariffs and competitive conditions.

Typically, European smelters average little more than 1.5 c/lb in their metal price premium. The Japanese receive about 7 cents, the Koreans 8-9 cents and North Americans about 6 cents. The highest current premium is received by the Thai smelter, which enjoys the protection of a 20 percent ad valorem import duty.

The range of smelter revenues in 1995 for these 17 projects would be from a low of $751/tonne for the French and Spanish smelters to $1,194 for the Thai ISF smelter. The three ISF smelters -- Japan, Thailand and New Brunswick -- would all generate over $1,000 of revenue per tonne.

Smelter Cost/Revenue Comparison

When comparing smelter full cost projections with the revenue projections we find that only one greenfield smelter surpasses the target rate of return. That is the Japanese ISF. The New Brunswick ISF falls short by only $24/tonne and the Thai ISF by $57. Of the greenfield electrolytic smelters, the Indonesian plant comes closest to target, falling $145 short.

Of the nine incremental expansions, five would meet or exceed their revenue targets. These would be Torreon, Onsan, Valleyfield, Risdon and Trail.

1995 SMELTER NET BALANCE COMPARISON

($/tonne metal)

Greenfield Smelters	Full Cost	Total Revenue	Net Balance
New Brunswick Electrolytic	$1,130	$878.10	(251.90)
New Brunswick ISF	1,113	1,089.13	(23.87)
Japan Electrolytic	1,419	872.25	(546.25)
Japan ISF	922	1,083.28	161.28
Thailand ISF	1,251	1,193.53	(57.47)
Queensland Electrolytic	1,060	865.89	(194.11)
Indonesia Electrolytic	1,025	879.60	(145.40)
France Electrolytic	1,108	750.98	(357.02)
Incremental Expansions			
Valleyfield	$775.15	$878.10	$102.95
Trail	835.97	865.37	29.40
Torreon	757.48	899.02	141.54
Risdon	798.04	870.74	72.70
Onsan	792.97	905.33	112.36
Iijima	951.89	872.25	(79.64)
Asturiana	829.48	750.98	(79.50)
Juiz de Fora	935.50	899.51	(35.99)
Cajamarquilla	1,133.99	901.01	(232.98)

Technical and Economic Considerations for a New Brunswick Smelter

As has been noted, a conventional electrolytic zinc smelter in New Brunswick would have full costs well above its projected revenue potential ($252/tonne). An ISF smelter would come much closer to meeting target ($24).

However, an ISF smelter may not be technologically feasible considering the unusual composition of New Brunswick bulk concentrates. Brunswick Mining tried to operate an ISF smelter many years ago, but could not achieve satisfactory results and the plant was converted to a lead smelter.

Two other smelting processes capable of treating New Brunswick concentrates are examined. The first is the Sherritt Gordon Pressure Leach (SGPL) process. The second is the Canmet FCL process.

The SGPL process would need a combination of zinc and bulk concentrates for its feed. The process eliminates roasting and, consequently, there is no SO_2 in off gases. This would eliminate the need for a sulfuric acid plant. Sulfur would be captured as elemental sulfur.

We calculate that an SGPL plant would have a lower capital cost per tonne than the electrolytic smelter but a higher capital cost than the ISF. Its operating costs would be higher than the electrolytic smelter but lower than the ISF. Its full cost of $1,105 would be a shade below both other processes. The cost/revenue comparison shows that the SGPL smelter would fall $87 short of meeting its target of achieving a 20 percent return on its equity investment.

The FCL process is specially designed to treat lower grade bulk concentrates, such as those produced in New Brunswick. Our calculations indicate that an FCL smelter would have very competitive costs. The capital cost per tonne would be less than the ISF and considerably less than the SGPL or electrolytic smelters. Operating costs would be less than the electrolytic, SGPL or ISF smelters. Full costs would be only $841/tonne.

However, it must be emphasized that this is an unproven technology. There is no operating experience from which to estimate costs.

Like the SGPL, the FCL smelter would not need an acid plant. It would also produce elemental sulfur.

The FCL would have a revenue of $1,463/tonne of zinc, yielding a positive balance $622 above the target needed to achieve a 20 percent return on its equity investment. The major uncertainty with FCL is whether it can, in fact, achieve the costs that have been assumed in these calculations.

We also examined the impact of an FCL smelter on the revenues of a mine supplying the bulk concentrates. The comparison for this calculation would be between a mine producing separate zinc, lead, copper and bulk concentrates and a mine producing a single bulk concentrate. The mine would lose revenue producing a single bulk concentrate, but the combined smelter and mine revenues would exceed those of a mine producing and selling separate concentrates.

A greenfield New Brunswick smelter could face increasingly stringent environmental regulations regarding disposal of iron residues, a product generated when leaching zinc oxides to increase metallurgical recovery of zinc. At present, the common management practice is impoundment of residues in tailings ponds. The most widely used technology, the jarosite process, is much less stable and generates more residue wastes than other processes such as hematite and goethite. A new plant could easily incorporate these latter processes.

The technological trend is moving towards treating the iron residues to recover the iron content. Thus, there is a potential upside risk of increasing capital and operating costs at most existing plants and all greenfield projects in industrialized countries.

Lastly, we examined the tax benefits offered under New Brunswick law that are aimed at encouraging further mineral processing within the Province. Credits for capital costs against the net revenue tax and the net profits tax could have considerable value, in the range of $79/tonne of zinc production under the FCL scenario to $91 with the ISF and $113 with SGPL.

These credits would more than offset the shortfalls for the ISF and SGPL smelters. They would make the FCL smelter even more profitable.

GLOSSARY OF TERMS

Primary zinc production. Zinc metal produced from the processing of mine output, i.e. ores.

Secondary zinc production. Zinc metal produced from the processing of zinc-containing scrap metal.

Greenfield smelter. A totally new smelter built at a new site. The cost of building a greenfield smelter includes the development of the necessary infrastructure.

Incremental expansion. The development of additional capacity at an already operating smelter through the installation of additional processing plant and equipment.

Zinc concentrates. The intermediary product between zinc ore and metal. Ore is milled or concentrated to raise the zinc content to a level suitable for smelting. Ore would typically contain 5-15 percent zinc while concentrate would grade 50-55 percent zinc.

Bulk concentrates. A concentrate containing recoverable amounts of zinc and lead. This is not a suitable raw material for an electrolytic zinc smelter. The Imperial Smelting Furnace was developed to treat bulk concentrates. Most mines produce a separate zinc concentrate or separate zinc and lead concentrates. However, some ores cannot be completely separated and a portion -- and in a few cases all --of the contained metal must be recovered in a bulk concentrate.

Electrolytic zinc smelter. The most widely used zinc smelting technology, which involves a three stage process of roasting, leaching and electrolysis. Only suitable for zinc concentrates. Sulfur dioxide is released in roasting. In most countries environmental regulations mandate that sulfur dioxide must be captured rather than emitted into the atmosphere. The captured gas is typically processed into sulfuric acid.

Imperial Smelting Furnace (ISF). A technology developed for the simultaneous smelting of zinc and lead. In most cases the concentrate feed is a blend of zinc concentrates and bulk zinc/lead concentrates. The zinc is recovered in marketable form, but the lead is recovered as a bullion which must then undergo refining. Precious metals contained in the concentrate feed typically report to the lead bullion and are recovered in the refining stage.

Sherritt Gordon Pressure Leaching (SGPL). A smelting process in which concentrates are subjected to high pressure leaching rather than roasting. The process is suitable for treating zinc concentrates or a blend of zinc and bulk concentrates. Because the roasting step is eliminated, no sulfur dioxide is created. The sulfur content of the concentrates is recovered as elemental sulfur. Lead is recovered in a residue which must subsequently be refined at a lead plant.

Ferric Chloride Leach (FCL). A smelting process developed by Canmet to treat lower grade bulk concentrates. No blending of zinc concentrates would be necessary. As with SGPL, no sulfur dioxide is created in this process and sulfur is recovered in its elemental form. This is the only process in which the lead content of the bulk concentrates would be recovered in a marketable form, i.e. no further refining would be necessary. This process is still in the developmental stage and has not been tested in a pilot plant.

Effective primary smelter capacity. The maximum output that a smelter has achieved in one year. Name plate capacity is the theoretical maximum level of production.

Treatment charge. The fee or deduction taken from the gross value of the concentrate to cover the cost of smelting. The miner is paid for a percentage of the zinc contained in the concentrate -- typically 85 percent -- less the treatment charge. In concentrate buying contracts the treatment charge is expressed in dollars per tonne of concentrate. The treatment charge is stated with a zinc metal reference price. When the actual market price is above or below the reference price the treatment charge is increased or decreased according to an established formula.

Net operating cost. The direct cost incurred by the smelter in producing a tonne of metal. It does not include capital repayment costs or corporate overhead charges. The value of by-product metals and sulfur recovered in smelting are deducted to calculate the net operating cost.

Full cost of production. Net operating cost, plus a corporate overhead charge plus capital repayment. In RSI's methodology the capital cost component includes a target rate of return on the equity portion of the capital investment. The interest rate imposed on the capital cost to develop an annualized capital cost is LIBOR plus 3 percent. This incorporates an assumed two-thirds debt financing at LIBOR and one-third equity financing returning 20 percent.

LIBOR. London Inter Bank Offering Rate. The most commonly used measure of interest rates available for corporate borrowing. Established and financially sound corporations can borrow at LIBOR, while less well established companies typically must pay a premium over LIBOR.

I. THE NEED FOR NEW ZINC SMELTER CAPACITY

I.1 Introduction

To determine the need for new zinc smelter capacity we must first develop a forecast of zinc demand through the year 2000. We will first present forecasts based on our base case macroeconomic outlook. At the end of this chapter we will also present a "downside" or bear forecast based on somewhat more pessimistic macroeconomic assumptions. These consumption forecasts are developed econometrically by RSI's zinc market forecasting model.

In the second stage of our analysis we have made assumptions that the model cannot generate. These deal with net East/West trade in zinc concentrates and zinc metal. These projected net trade balances must be added to or subtracted from non-Socialist world metal consumption to derive projections of needed non-Socialist world mine and metal production to meet the level of total demand.

Metal supply comes from primary sources (mine production) and secondary sources (recyclable zinc-bearing scrap). Primary production is a function of mine capacity, mine operating rates and metallurgical losses in converting concentrates to metal. RSI maintains a mine-by-mine database of capacity through 1994. Thus, mine capacity through 1994 is an exogenous variable input into the market model. Mine capacity growth in the 1995-2000 period is generated by the model. Year-by-year variations in mine capacity growth are a function of a lagged price response. The logic of the forecasting equation is that high prices will stimulate new capacity development at a higher rate than the projected growth in demand. Low prices will develop less new capacity than the projected growth in demand. Thus, capacity growth will be uneven year-to-year based on the level of zinc prices in preceding years. This has been the historical pattern in the industry and the model seeks to capture that investment pattern. Mine operating rates are a function of prices and stock levels in the current and the preceding year. Naturally, high prices stimulate maximum achievable production while low prices stimulate production curtailments. The forecasting equation incorporates the metal price and the industry production cost schedule. During periods of low prices the cost schedule determines how much production would be forced offstream at different price levels.

The need for new mine capacity, and hence mine production, is also a function of how much metal demand will be met by secondary sources. Historically, it was possible to relate secondary production to metal prices, current levels of industrial activity and the pool of zinc-containing goods. Zinc recycling in the past was restricted to products made entirely of zinc, e.g. zinc die casting and roofing sheet, and zinc-bearing alloys, e.g. brass mill products. Since zinc-bearing alloy scrap is simply remelted and cast into brass mill shapes, alloy scrap could be ignored in forecasting secondary refined zinc production.

In recent years, however, progress has been made in recovering the zinc content of recycled galvanized steel. Thus, we have had to adjust our secondary zinc production forecast to incorporate the increasing supply coming from recycled galvanized steel.

The final stage in this analysis is to forecast the need for new smelter capacity. As with mine capacity, RSI maintains a smelter-by-smelter capacity database through 1994. After adjusting name plate smelter capacity to effective operating capacity we can determine the year-by-year balance through 1994 of concentrate supply and concentrate capacity to treat that supply.

We will then hold smelter capacity constant at the 1994 level and compare that with our projections of concentrate supplies (mine production adjusted for net East/West concentrate trade) to determine when new smelter capacity will be needed and how much.

After having completed this mine/smelter balance for the entire non-Socialist world, we will estimate what the regional balances will look like under our base case scenario. We will apply our judgement in allocating mine production by region based on 1) our knowledge of reserve life at existing mines, i.e. which mines will be depleted in the 1995-2000 period and 2) our knowledge of where the most promising, but as yet uncommitted, orebodies are located.

We will also project demand by region, net out secondary supply, and then develop regional balances of primary metal demand, local concentrate production and 1994 smelter capacity. This will be valuable in trying to determine where new smelter capacity is most likely to be developed. A region with growing metal demand, growing concentrate supplies and smelter capacity inadequate to match demand or to treat local concentrate supplies would obviously be a good candidate for new smelter capacity. A region with smelter capacity in excess of both local demand and local concentrate supply would obviously be a poor candidate for new smelter capacity.

This analysis would provide us with only one indicator of where new smelter capacity would be likely. Smelter economics would also be another major consideration and this will be examined in a subsequent chapter.

I.2 Zinc Market Forecast Overview

Before turning to a more detailed discussion of projected zinc consumption and production, we will first present a summary of our market outlook through 2000.

The zinc market has been soft since 1989. Consumption this year is projected to match 1988. However, mine capacity over the 1989-1990 period will have increased by 400,000 tonnes. Mine operating rates have fallen from 91.6 percent of capacity in 1989 to 88.6 percent this year. As a result, mine production this year will be only 255,000 tonnes more than 1988.

Despite the lower mine operating rates, production has been running ahead of demand and world stocks have risen from 350,000 tonnes at the end of 1988 to a projected 528,000 tonnes at the end of 1991.

As a result, prices have fallen from an annual average of 78 cents in 1989 to about 50 cents in mid-1991.

We expect demand to rebound next year but this will only bring supply and demand into balance. A factor in preventing the market from moving into deficit will be continued net exports from the East Bloc. Since 1989 there has been a 120,000 tonne swing in East/West trade in slab zinc. The East was a net importer of 42,000 tonnes in 1989 and in 1991 we are projecting net East Bloc exports of 80,000 tonnes.

We look for another strong gain in consumption in 1993, but production is expected to increase by about the same amount. While the absolute level of stocks will not yet show a decline, the index of stocks to consumption will begin to retreat and we expect prices to begin to recover. In constant 1990 U.S. dollar terms, our forecast for 1993 is 59.8 cents.

We expect stocks to begin to decline in 1995. We are projecting a resumption of East Bloc net imports in 1996, with the tonnage rising steadily to 100,000 tonnes by 2000. This will act to keep total demand a bit ahead of refined production over the second half of the decade. Constant dollar prices will move into the mid-60 cent range. By 2000 stocks are seen falling below 0.85 months worth of consumption and this would spark a price rally to over 75 cents (in 1990 U.S. dollar terms).

Thus, we feel that prices will begin to rise in 1993 and should hold at over 60 cents (in 1990 U.S. dollar terms) over the rest of the decade.

WORLD ZINC FORECAST SUMMARY

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Consumption	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
% Change	-1.5	-4.2	7.6	3.2	0.9	3.1	3.2	4.7	-1.0	1.0
Mine Capacity	5437.0	5588.0	5493.0	5604.0	5584.0	5626.0	5645.0	5668.0	5715.0	5879.0
Operating Rate	82.0	86.0	87.8	91.0	92.3	88.5	91.2	90.3	91.6	91.0
Mine Production	4459.0	4804.0	4823.0	5100.0	5152.0	4978.0	5149.0	5120.0	5237.0	5350.0
% Change	-1.2	7.7	0.4	5.7	1.0	-3.4	3.4	-0.6	2.3	2.2
Refined Production	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
% Change	1.8	-4.9	6.8	6.1	2.1	-2.8	4.2	3.6	-0.4	-0.7
Inventory Level	638.0	595.0	442.0	449.0	440.0	450.6	411.7	349.5	430.6	391.7
Months Consumption	1.73	1.69	1.16	1.15	1.11	1.11	0.98	0.79	0.99	0.89
LME Price, c/lb	38.9	33.7	34.7	40.5	36.2	34.3	36.2	56.3	77.6	68.8
% Change	12.9	-13.4	3.0	16.5	-10.4	-5.2	5.4	55.4	38.0	-11.3
Real Price, 1990 c/lb	48.3	40.2	40.7	46.5	41.3	39.7	40.9	62.1	81.5	68.8

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Consumption	5284.3	5471.7	5650.0	5779.4	5884.1	5964.3	6091.0	6223.7	6373.6	6479.6
% Change	0.1	3.5	3.3	2.3	1.8	1.4	2.1	2.2	2.4	1.7
Mine Capacity	6067.0	6123.0	6366.0	6472.0	6541.6	6655.3	6787.0	6924.3	7118.0	7307.9
Operating Rate	88.6	88.2	88.1	88.9	89.0	89.3	89.5	89.9	90.3	90.6
Mine Production	5374.6	5400.0	5609.3	5756.3	5820.2	5943.1	6071.4	6221.7	6431.0	6619.0
% Change	0.5	0.5	3.9	2.6	1.1	2.1	2.2	2.5	3.4	2.9
Refined Production	5340.8	5419.8	5635.0	5789.3	5863.5	5976.7	6103.8	6245.5	6442.0	6577.7
% Change	3.0	1.5	4.0	2.7	1.3	1.9	2.1	2.3	3.1	2.1
Inventory Level	528.2	536.2	551.2	561.1	540.5	532.9	505.7	467.5	455.9	454.0
Months Consumption	1.20	1.18	1.17	1.17	1.10	1.07	1.00	0.90	0.86	0.84
LME Price, c/lb	50.8	54.8	66.0	69.7	73.1	77.0	81.2	86.1	91.0	111.4
% Change	-26.3	8.0	20.4	5.6	4.9	5.3	5.3	6.1	5.7	22.4
Real Price, 1990 c/lb	49.6	51.6	59.8	60.8	61.5	62.3	63.1	64.3	65.4	76.9

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I.3 Zinc Consumption Forecast

The macroeconomic assumptions underlying our zinc consumption forecast contained in Appendix A. Our view is that the recovery from the current economic downturn will be fairly moderate. Gross National Product (GNP) growth rates in 1992 will be considerably higher than the depressed levels of 1991, but it will be 1993 before a strong level of economic growth is achieved. Growth rates will then be moderate over the 1994-1995 period.

We have not attempted to incorporate cycles into our economic forecasts for the second half of the decade. The trend growth rates used for GNP and Industrial Production (IP) are as follows:

MACROECONOMIC INDICATORS
AVERAGE ANNUAL % GROWTH
1995-2000

COUNTRY	GNP	IP
United States	**2.5**	**2.5**
Canada	**2.5**	**3.0**
Western Europe	**2.95**	**2.8**
Japan	**3.8**	**3.0**

Zinc consumption in the non-Socialist world is projected to increase by an average rate of 2.1 percent per year over the 1991-2000 decade. Zinc demand has been virtually stagnant since 1988. Our forecast level for 1991 is the same as the 1988 total. We project a strong 3.5 percent rebound next year and another solid 3.3 percent gain in 1993. We then see growth slowing to 2.3 percent and 1.8 percent through 1995. Annual average growth over the 1996-2000 period is projected at 2.0 percent, with a range of 1.4 - 2.4 percent.

Growth in the industrial world is expected to be much less than in the emerging economies. The average growth rates over the decade are projected at 1.5 percent in the US, 1.4 percent in Japan and 1.6 percent in Europe.

The projected increase in consumption over the decade is 1,199,000 tonnes. We believe that 48 percent of that growth -- or 576,000 tonnes -- will be in the Australasia region. We expect North American demand to increase by 236,000 tonnes -- 159,000 in the US, 37,000 in Canada and 40,000 in Mexico. We project an increase of 290,000 tonnes in European consumption, 65,000 in South American demand and only 29,000 in African/Mideastern consumption.

The pattern of zinc end-use demand has changed dramatically over the last 20 years and we believe the trend that emerged over that period will persist through 2000. In 1970, non-Socialist world consumption stood at 3,898,000 tonnes. The galvanized steel market accounted for 34 percent of total demand, die casting took 23 percent, brass mill products 23 pecent and all other markets 20 percent.

By 1980 the end-use shares were galvanizing 36 percent, die casting 18 percent, brass 24 percent and others 22 percent. This trend continued and in 1989 market shares were galvanizing 43 percent, die casting 15 percent, brass 24 percent and others 18 percent.

Of the 1,333,000 tonne increase in consumption from 1970 to 1989, 69 percent or 924,000 tonnes was in the galvanizing sector.

We believe that by 2000, galvanizing will account for 49 percent of total zinc demand. Of the total increase in consumption of 1,249,00 tonnes that we project from 1989 to 2000, we believe that galvanizing will account for 74 percent or 924,000 tonnes.

Let us now examine the trends within zinc's main markets.

GALVANIZING: There has been a clear trend over the 1980s toward improving product quality and extending product life. The concept of assessing the cost of a product over its useful life, rather than simply considering its cost of purchase, is now much more widely accepted. This has clearly benefitted galvanized steel. For example, it costs more to build a bridge with galvanized steel than with uncoated carbon steel. However, maintenance costs of the galvanized steel bridge are much less and life of the bridge is extended. The total cost over the life of the galvanized steel bridge are much less despite the higher initial cost.

The trend toward extending the life of the product has been most dramatic in the automobile industry. Major efforts have been made to extend the life of car bodies through the increased use of coated steel. The coatings may be pure zinc or zinc-containing alloys. In 1984, the zinc content of steel going into US autos averaged 6 lbs. By 1990 the zinc content had increased to 12 lbs.

Today, 80 percent of the steel going into US cars is coated. The same trend is taking place in Europe and Japan, but it has been slower in developing than in the US. Today, about 40 percent of the steel in European cars is coated, while in Japan it is about 50 percent. In Japanese export cars the amount is 80 percent.

European and Japanese car makers may not move up to the 80 percent penetration already acheived in the US, but a 60 - 70 percent share for coated steel seems likely. In Europe, galvanized steel capacity doubled between 1983 and 1989 and is scheduled to increase from 11.5 mn tonnes in 1989 to 15 mn by 1993. Most of this new capacity is aimed at the auto market.

A considerable amount of research and development work is going on toward achieving coatings that are superior to conventional zinc-coated galvanized steel. Improvements are also being continually made in the deposition of the coatings on to the steel. These technological developments make it difficult to forecast the amount of zinc that will be contained per tonne of coated steel five or ten years from now.

However, it is clear that coated steel's share of total steel production will continue to increase. Between 1980 and 1988 the share rose from about 6 percent to over 11 percent. Zinc consumption in coated steel will probably not match the growth in the use of coated steel, but it should be almost as strong.

Our expectations for continued strong growth in the galvanizing sector ties into our projection that nearly half of the growth in zinc consumption to 2000 will be in Australasia.

The fastest growing economies in the world are in the Far East. Many of the emerging Asian economies are moving into the basic infrastructure stage of development. This is a very steel intensive stage of economic development and much of that steel is galvanized. The zinc intensity of industrial infrastructure development is apparent from the Japanese experience of the 1960s -- zinc consumption more than tripled in that decade. This same phenomenon was repeated in Korea during the 1980s. Again, zinc consumption more than tripled in a decade. We expect to see the same pattern in such countries as Indonesia, Thailand and Malaysia during the 1990s.

DIE CASTING: During the 1960s die casting was the fastest growing market for zinc, although a disproportionate share of this growth was in the US. In 1965, die casting accounted for 38 percent of US zinc consumption, as against 28 percent for galvanizing. In the other major industrialized countries die casting's market share peaked at about 15 - 20 percent.

The US die casting market reached 596,000 tonnes in 1965. By 1989 it had fallen to 220,000 tonnes. The entire non-Socialist world market for zinc die castings was only 785,000 tonnes in 1989.

The overwhelming share of this market loss took place in the automotive sector. Following the first oil shock a major program was launched to reduce vehicle weight to improve gasoline consumption. Many decorative die cast parts were simply eliminated. Other zinc die cast parts were replaced by plastics or aluminum. Finally, the development of fuel injection eliminated the carburetor, the single largest automotive zinc die cast part.

Interestingly, in countries where the auto sector was never an important zinc die casting market, consumption has continued to grow. Between 1960 and 1989 the French zinc die casting market nearly doubled, while in Germany it nearly tripled.

The die casting market now seems to be stabilizing. The development of thin wall die casting has reduced the zinc content of cast parts, but has helped ward off total replacement. There will continue to be strong competition from plastics and aluminum, but we believe that growth in the product lines where zinc die castings have a competitive advantage should translate into modest overall consumption growth. We are projecting that the market will expand by 45,000 tonnes to reach 830,000 tonnes in 2000. This would still be 67,000 tonnes less than were consumed in 1970.

BRASS: Consumption of zinc in brass mill products increased from 897,000 tonnes in 1970 to 1,255,000 in 1989. That is a 40 percent increase over 19 years -- a modest but steady growth rate.

Zinc consumption in brass mill products has been held back by the combined effect materials substitution and economization. Aluminum is gaining a greater share of the auto radiator market, while in plumbing applications plastics have made significant inroads. Tonnage losses through economization are the result of improved manufacturing techniques. In other words, a brass part can fill the same function as in the past, but with less metal contained in the past (e.g., through thinner gauge sheet or tube).

We do not see any major changes in the brass market. The inherent characteristics of these copper based alloys make them the preferred material in many applications where high performance is important. We are projecting a modest growth of 13 percent in this market from 1989 to 2000. This would amount to 165,000 tonnes and would lift the size of this market to 1,420,000 tonnes.

OTHER USES: This catchall category is made up of zinc sheet and strip and zinc chemicals. Zinc sheet is a popular roofing material in France and Germany, but not anywhere else. This market has been fairly stable at around 90,000 - 100,000 tpy in France and 70,000 - 75,000 tpy in Germany. Growth will be very moderate at best.

In the US zinc strip is used to make one cent coins. This market consumes about 25,000 tpy and very little growth is expected. Another market for zinc strip is in dry cell battery casings. Newer battery types do not use zinc casings, but the older zinc encased batteries still predominate in the developing world because they are cheaper. Little overall growth is expected in the zinc strip market.

The main chemical application of zinc is as zinc oxide in rubber manufacture. The development of radial tires has greatly increased tire life and this has impacted demand for zinc oxide. However, this has been a once-only downward adjustment and consumption in the future should parallel the growth in tire manufacturing.

Thus, while zinc consumption in this "other use" category fell from 988,000 tonnes in 1980 to 942,000 in 1989, we feel that the major downward adjustment is past and that modest growth will be resumed. We project demand in 2000 at 1,053,000 tonnes.

WESTERN WORLD ZINC CONSUMPTION BY END-USE
(000 tonnes)

	1970	%	1980	%	1989	%	2000	%
Galvanizing	1325	34	1617	36	2249	43	3174	49
Die Casting	897	23	808	18	785	15	831	13
Brass	897	23	1078	24	1255	24	1421	22
Other	780	20	988	22	942	18	1054	16
TOTAL:	3898	100	4491	100	5231	100	6480	100

WESTERN WORLD REGIONAL ZINC CONSUMPTION FORECAST
(000 tonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
North America											
USA	997	950	1011	1049	1085	1092	1089	1097	1108	1136	1156
Canada	126	126	130	136	143	147	150	153	156	160	163
Mexico	110	105	110	115	120	125	129	134	139	144	150
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TOTAL:	1233	1181	1251	1300	1348	1364	1368	1384	1403	1440	1469
Europe	1912	1915	1957	1999	2019	2057	2081	2115	2151	2178	2202
Australia											
Japan	814	850	874	899	901	905	904	921	939	968	956
Korea	227	255	266	280	291	303	312	328	343	359	374
Australia/ New Zealand	89	84	93	99	105	115	120	122	127	130	133
Other East Asia	465	492	512	542	569	583	609	638	665	684	709
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TOTAL:	1595	1681	1745	1820	1866	1906	1945	2009	2074	2141	2172
South America	265	235	244	254	265	275	285	295	305	320	330
Africa/Middle East	276	273	275	278	280	282	285	288	292	298	305
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TOTAL WESTERN WORLD:	5281	5284	5472	5650	5779	5884	5964	6091	6224	6374	6480

I.4 Zinc Mine Production Forecast

Non-Socialist world mine capacity in 1991 stands at 6,067,000 tonnes. In 1994 we project that it will reach 6,472,000 tonnes. Our mine-by-mine capacity tabulation is carried in Appendix B. In this section we will simply highlight the significant additions and subtractions over the 1992-1994 period.

In 1992, mine capacity will increase by only 56,000 tonnes. Canadian capacity will hold steady despite a 25,000 tonne gain from Mt. Hundere as it moves up toward capacity. This will be offset by reductions in capacity at Heath Steele, Kidd Creek, Nanisivik and Geco.

US capacity will rise by 24,000 tonnes as Red Dog approaches design capacity. In Australia only 10,000 tonnes of increased capacity will come onstream as Hellyer, Hilton and Thalanga reach or approach their capacities. In Mexico, Penoles' Rey de Plata will add 9,000 tonnes and Real de Angeles 7,000.

In Morocco we expect 20,000 tonnes of additional capacity from the expansion of Douar Hajar, while in India, Rampura-Agucha will add 20,000 to its 1991 startup capacity. In Mexico, an expansion at IMMSA's Charcas mine should add 15,000 tonnes.

Offsetting much of this new capacity will be a 65,000 tonne drop at existing mines. In Finland, Outokumpu's 17,000 tpy Pyhasalmi mine will close at end-1991, while the 40,000 tpy Vihanti mine will go offstream at mid-year. In Germany, Metaleurop's 25,000 tpy Bad Grund mine will close. Spanish capacity will fall by 36,000 tonnes with the closure of Rubiales and Silicatos and reduced capacity at Troya. In the UK we assume 7,000 of Parys Montain's 15,000 tonne capacity will come onstream.

We expect that mine production will increase very little next year as the depressed prices of 1991 will push industry-wide operating rates down from 88.6 percent this year to 88.2 percent.

In 1993 we expect to see a surge in new mine capacity of 243,000 tonnes. There is, however, a fair amount of uncertainty surrounding some of the projects going into this tabulation. The main assumptions we have made are that Cirque and MacDonald come onstream in Canada, Bougrine starts up in Tunisia, Chessy comes onstream in France, and Bismark is launched in Mexico. We had originally scheduled Bismark for a 1992 start, but have now pushed it back a year.

In 1994 we project a further 106,000 tonne increase in capacity, but there is considerable uncertainty in this case as well. We have assumed that Cayeli would start up in Turkey and Galmoy would come onstream in Ireland at 70,000 tpy. There are two major projects under study in Ireland - Galmoy and Lisheen. Each could produce about 70,000 tpy, but neither is certain at this point. We have taken a middle road in assuming that half of the potential capacity will be operational by the start of 1994.

The major losses in capacity over the 1993-1994 period would come from the closure of Vihanti in Finland, Meggen in Germany, Aznalcollar in Spain and Graciela in Peru.

NET CHANGES TO MINE CAPACITY

(000 tonnes)

	1992	1993	1994
Austria			
Bleiberg			-18
Finland			
Pyhasalmi	-17		
Vihanti	-19	-21	
France			
Chessy		+12	+14
Germany			
Bad Grund	-22	-3	
Meggen		-35	
Ireland			
Galmoy			+70
Italy			
Masua	-5		
Monteponi	+8		
Portugal			
Aljustrel	+14	+3	
Spain			
Rubiales	-33		
Silicatos	-4	-5	
Aznalcollar		-16	-49
Troya	-5	-2	-2
Reocin	+6	+3	
Sweden			
Knallagruvan	+10		
United Kingdom			
Parys Mt.	+7	+8	
Morocco			
Douar Hajar	+20	+25	
Tunisia			
Bougrine		+35	+35
India			
Rampura - Agucha	+20	+15	

NET CHANGES TO MINE CAPACITY
(000 tonnes)

	1992	1993	1994
Turkey			
Rize Cayeli			+35
Canada			
Mobrun	+3	+3	
Mt. Hundere	+35	+6	
Cirque		+60	+60
MacDonald		+25	
Nanisivik	-8	-8	-5
Geco	-7		-2
Myra Falls	+3	+15	
Heath Steele	-6	-7	
Kidd Creek	-10		
Lyon Lake	-5		
USA			
Red Dog	+30	+25	
Magmont			-6
Ward	-3		
Bunker Hill	-5		
Van Stone	+4		
Brazil			
Januaria	+11	+11	
Morro Agudo	+12	+11	
Mexico			
Charcas	+15		
Bismark		+50	
Real de Angeles	+7	+6	+2
Rey de Plata	+9		+6
Peru			
El Porvenir	-6	+7	
Graciela	-6	-14	-43
Huaron	-6		
Australia			
Scuddles		+5	
Peak		+3	
Hellyer	+5		
Que River	-9		
Hilton	+10	+10	+5
Thalanga	+4	+3	+4
Others	-7	+13	—
Total Net Change(+/-)	+56	+243	+106

Operating rates are expected to remain low in 1993, but because of the surge in new capacity, mine production is forecast to increase by 209,000 tonnes. In 1994, with some improvement in operating rates, mine output moves up by another 147,000 tonnes.

As explained earlier, capacity increases over the 1995 - 2000 period are forecast by our zinc market model based on the projected growth in consumption and metal prices. Here are the year-by-year projections of mine capacity and mine production over that period.

MINE CAPACITY FORECAST
1995-2000
(000 tonnes)

	CAPACITY ADDITIONS	PRODUCTION INCREASES	MINE OPER. RATE %
1995	70	64	89.0
1996	113	123	89.3
1997	132	128	89.5
1998	137	151	89.9
1999	194	209	90.3
2000	190	188	90.6

The increasing amount of new capacity development and the steady rise in mine operating rates both reflect our expectation of rising real prices over the second half of the decade. From 61.5 cents in 1995, the constant 1990 dollar price rises steadily to 76.9 cents in 2000.

We must caution that the investment pattern incorporated in our model replicates historical behavior but cannot guarantee that the future will unfold in a similar manner. In actuality, we believe that the development of small and medium sized projects do indeed reflect the lagged price response. However, a major mine project with very attractive costs could proceed even if prices are not very attractive at the time of the investment decision.

To take this discussion from the theoretical to the specific, the giant Century deposit of CRA in Australia could produce a huge surge in capacity by as early as 1995. This mega-project could produce as much as 400,000 tpy of zinc in concentrate. Were the project to be brought onstream all at once in 1995, it would create a major supply surplus and drive prices well below those forecast by our model. However, plans for this project are still under development and it is possible that Century could be developed on a smaller scale or that there could be phased development so that ultimate capacity would not be reached for some years after startup. Therefore, we will proceed with our analysis based on our model-generated scenario, with the caveat that Century could upset the apple cart.

It is not possible to assign the model-generated capacity to specific countries with any high degree of certainty, especially in the latter years of the decade. However, we are aware of several projects that could be onstream in the 1995 - 2000 period and we will make an attempt to allocate the projected capacity geographically so that we can try to determine where new smelter capacity will probably be developed. Our projections of regional consumption will also go into this assessment.

There is one additional step to this analysis and that is to estimate how much capacity will go offstream over 1995 - 2000 due to ore depletion. It is difficult to predict how much mine capacity will be depleted each year. In the 1977 - 1986 period the average was 97,000 tpy. In the 1987 - 1990 period the average was 184,000 tpy. These numbers equate to 2 percent per year and 3 percent per year. Based on the tabulated 1994 capacity, this would mean closures over the six years to 2000 would be between 739,000 tonnes (or 123,000 tpy) and 1,081,000 tonnes (or 180,000 tpy).

If we apply a 2.4 percent per year ore depletion rate, capacity from mines operating in 1994 would decline as follows:

MINE CAPACITY DEPLETION 1994-2000
(000 tonnes)

1994	1995	1996	1997	1998	1999	2000
6472	6317	6165	6017	5873	5732	5594

The total loss due to ore depletion from 1994 to 2000 would be 878,000 tonnes. Of that total, we have identified ore depletions totalling 595,000 tonnes. These are as follows:

MINE CLOSURES 1995-2000
(000 tonnes)

	CAPACITY	YEAR OFFSTREAM
Canada		
Geco	26	1996
Heath Steele	35	1997
Isle Dieu	53	1997
Nanisvik	36	1996
Polaris	155	1999
Selbaie Al Zone	35	1997
Sullivan	108	1999
Australia		
Black Mountain	27	1999
Cadjebut	61	1995
Woodcutters	42	1996
Spain		
Troya	17	1996

We have apportioned the other unidentified capacity losses of 283,000 tonnes over the period into the following regions: Europe 56,000, Africa 27,000, Asia 34,000, US 45,000, Mexico 27,000, Peru 45,000, other Latin America 24,000, Australia 25,000. Thus, we can alter the average 2.4 percent depletion rate to incorporate known data as to ore reserves and produce the following regional mine capacities for mines operating in 1994.

REGIONAL MINE CAPACITY ADJUSTED FOR ORE DEPLETION

(000 tonnes)

	1994	1995	1996	1997	1998	1999	2000
Europe	838	829	803	794	785	775	765
Africa	402	398	393	389	384	380	375
Asia	512	509	503	498	492	486	480
Canada	1481	1481	1419	1296	1296	1033	1033
US	703	696	688	681	673	666	658
Mexico	417	413	408	404	399	395	390
Peru	650	643	635	628	620	613	605
Other L.A.	392	386	382	378	374	370	366
Australia	1077	1012	966	963	958	927	922
TOTAL	6472	6367	6197	6031	5981	5645	5594

We will now be able to estimate the amount of new capacity that must be developed over the 1995 - 2000 period to cover the growth in the market and the losses from mines operating in 1994.

MINE CAPACITY REQUIREMENTS 1994-2000

(000 tonnes)

	1994	1995	1996	1997	1998	1999	2000
Total Projected Capacity	6472	6542	6655	6787	6924	7118	7308
Capacity From Mines Operating In 1994	6472	6367	6197	6031	5981	5645	5594
Needed New Capacity	---	175	458	756	943	1473	1714

On an annual basis, the need for new capacity would be as follows:

ANNUALIZED MINE CAPACITY REQUIREMENTS
1995-2000
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Needed New Capacity	175	283	298	187	530	241

Of the 1,714,000 tonnes of new capacity, we have identified projects that could yield 1,524,000 tonnes. Obviously, some of these prospects will fall by the wayside while other properties that have yet to be discovered will be in operation by 2000. However, in order to build up our regional balances, we will include these projects in our capacity tabulations (000 tonnes).

POTENTIAL ZINC PROJECTS 1995 - 2000

(000 tonnes)

REGION	COMPANY	PROJECT	CAPACITY
Canada			
	Breakwater	Mel	30
	Cameco/Trimin	Hanson Lake	34
	Equinox	J & L	10
	Marshall	Restigouche	28
	Noranda	Louvicourt	20
	Cominco	Tulsequan	30
	VSM	Grevet	50
	TOTAL		202
Australia			
	CRA	Century	400
	MIM	McArthur River	120
	Pasminco	Dugald River	125
	Falcona	Mt. Garnet	35
	Pancontinental	Lady Loretta	50
	Diversified	Silver King	7
	Plutonic	Balcooma	60
	TOTAL		797
United States			
	Boliden	Bald Mountain	15
	Echo Bay	Lik	70
	Resource Finance	Pend Oreille	10
	Noranda	Lynne	28
	TOTAL		123
Peru			
	Minero Peru	Iscaycruz	45
Chile			
	Lac	El Toqui	20
Europe			
Spain			
	Billiton	Aguas Tenidas	50
	Boliden	Los Frailes	80
Ireland			
	Invernia West	Lisheen	70
Portugal			
	Somincor	Neves Corvo	30
Africa			
Burkina Faso			
	Kaliden	Perkoa	70
Asia			
Iran			
	Government	Yazd	25
India			
	Gujarat	Ambamata	12
GRAND TOTAL:			1,524

Of the remaining 190,000 tonnes of capacity we calculate will be developed over the 1995 - 2000 period, we have apportioned that tonnage as follows: Canada 32,000; Australia 27,000; US 14,000; Mexico 19,000; Peru 22,000; other Latin America 24,000; Europe 14,000; Africa 19,000 and Asia 19,000.

Based on these projected tonnages we will now estimate regional mine capacity by year over the 1995 - 2000 period. Our projections of total mine capacity and our assumptions as to capacity depletions have given us total new capacity numbers by year. For some of the potential new projects we will estimate a start-up year. For the remainder, we will spread the new capacity over the period.

REGIONAL ZINC MINE CAPACITY
(000 tonnes)

	1994	1995	1996	1997	1998	1999	2000
Europe	838	879	883	892	902	969	1009
Africa	402	398	426	457	452	467	464
Asia	512	524	523	523	522	542	536
Canada	1481	1496	1479	1391	1416	1233	1267
US	703	711	713	731	743	771	795
Mexico	417	413	408	404	399	414	409
Peru	650	643	635	638	640	665	672
Other L.A.	392	406	402	398	402	406	410
Australia	1077	1072	1186	1353	1448	1651	1746
TOTAL:	6472	6542	6655	6787	6924	7118	7308

The next step is to convert these capacity numbers to production numbers. The market model has developed capacity utilization numbers for each year for the total non-Socialist world so as to produce annual mine production numbers. However, we will not apply the same operating rate for each year to each region. Historically, some regions have consistently achieved higher operating rates than others. For example, Australian operating rates in recent years have been in the high 90 percent range, while Peruvian operating rates have been in the mid 80 percent range. Thus, we will apply our judgement, based on historical behavior, to develop the regional breakdown of projected mine production. This is set forth in the following table:

REGIONAL ZINC MINE PRODUCTION
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Europe	804	812	821	835	903	940
Africa	334	358	384	380	399	395
Asia	444	446	445	444	465	458
Canada	1372	1362	1288	1313	1147	1180
US	618	620	636	650	680	710
Mexico	366	363	359	358	373	370
Peru	540	533	536	542	567	574
Other L.A.	337	334	330	339	343	346
Australia	1005	1115	1272	1361	1554	1646
TOTAL:	5820	5943	6071	6222	6431	6619

I.5 Zinc Smelter Capacity Forecast

RSI's tabulation of smelter capacity by unit through 1994 appears in Appendix C. Capacity in 1991 is 6,030,000 tonnes. By 1994 it is expected to reach 6,407,000 tonnes.

All of the smelters in this tabulation are primary smelters (i.e., they treat concentrates). However, some of them also take in secondary materials as part of their feed. This would include galvanizing drosses, upgraded and processed zinc bearing steel mill flue dust, etc. Very rarely do smelters report how much of their slab production is based on concentrates and how much is based on secondary materials. Thus, it is difficult to estimate how much of the capacity in our tabulation is dedicated to treating concentrates.

The International Lead and Zinc Study Group does report secondary refined zinc by country. However, some of this is produced by smelters dedicated to re-refining secondary materials. There are not many such facilities. Most secondary zinc plants are remelt operations, not refiners. Remelted zinc is excluded from all tabulations of refined zinc production and consumption. Later in this chapter we will develop estimates of effective primary zinc capacity by country. At that time we will factor in our estimates of the amount of secondary refined zinc produced at primary smelters and dedicated secondary refiners.

The smelter capacity expansions scheduled over the 1992-1994 period are presented in the following tables.

Capacity will increase by 116,000 tonnes in 1992. This will come from the following:

- **Expansion of the Asturiana smelter in Spain (65,000 tonnes),**
- **Expansion of Inga's small Portuguese smelter (13,000),**
- **Expansion of Inga's Brazilian smelter (18,000),**
- **Expansion of Penoles' Mexican smelter (15,000),**
- **Expansion of Korea Zinc's Onsan smelter (10,000),**
- **First full year of production from Hindustan Zinc's ISF smelter in India (20,000),**
- **Offsetting some of this new capacity will be the closure of Bleiberger's smelter in Austria (25,000)**

In 1993 smelter capacity is scheduled to rise by 91,000 tonnes, from the following sources:

- **The completion of Inga's Brazilian expansion (38,000 tonnes),**
- **A small expansion of Paraibuna's Brazilian smelter (3,000),**
- **Completion of Korea Zinc's expansion (10,000),**
- **Full capacity operation of Hindustan Zinc's new ISF (15,000),**
- **The expected startup of a small smelter by Hindustan Chemicals in India (20,000),**
- **Expansion of Cinko Kursun's smelter in Turkey (5,000).**

We expect capacity in 1994 to increase by 170,000 tonnes, from the following projects:

- **A new ISF in Japan involving Nippon Mining, with the possible inclusion of Mitsui and Mt. Isa (120,000 tonnes),**
- **Completion of the second stage of the expansion of Penoles' Torreon smelter in Mexico (50,000).**

The capacity additions listed above are not all absolutely certain. The current economic crisis in Brazil casts some doubt on Inga's ambitious plans. The major uncertainty, however, is in Japan. Nippon Mining wants very much to proceed with a new ISF that would produce 120,000 tpy of zinc and 60,000 tpy of lead. Mitsui and Mt. Isa are considering joining in the venture. The plan is to take bulk concentrates from Mt. Isa and to also treat zinc steel mill flue dust. The bulk concentrates could come from the Mt. Isa/Hilton complex or they could come from development of the McArthur River project. The complex metallurgy of McArthur River means that only a bulk concentrate could be produced. The difficulties in getting agreement to launch this project stem from Mt. Isa's current financial problems -- it is presently running losses due to depressed metal prices -- and Mitsui's indecision as to what course it wishes to follow. Mitsui is also considering expanding Hikoshima from 84,000 to 139,000 tpy. Complicating matters further, Akita Zinc is considering expanding Iijima from 156,000 tpy to 240,000 tpy.

The smelters and the Ministry of International Trade and Industry (MITI) are trying to determine which projects should go ahead. It is the government's policy that capacity should not expand faster than domestic demand. Exports, which now run at a modest 20,000 tpy, will not be increased, according to MITI's plan. Further complicating matters in the "gentlemen's agreement" that the existing market shares held by the smelting companies should not be significantly altered. Thus, we believe that when new capacity is built, some older and less efficient capacity will be closed. Nikko Zinc's (Nippon's) 100,000 Mikkaichi smelter is considered one prime candidate for closure. We will deal with this problem when we develop projections of Japanese capacity over the 1995 - 2000 period.

We should also note that while our unit-by-unit tabulation of smelter capacity extends only through 1994, there has just been an announcement of a new smelter that would come onstream at the end of 1994 or the start of 1995. Padaeng has announced plans to build a new ISF with a capacity of 60,000 tpy of zinc and 40,000 tpy of lead. Metalgesellschaft, which conducted the feasibility study through its engineering subsidiary, Lurgi, will hold 49 percent of the equity. Three-quarters of the zinc output would be targeted for export through MG. We are very skeptical about the economic viability of this project and it will be closely examined later in this report.

We will now attempt to convert the 6,407,000 tonnes of smelter capacity we have tabulated for 1994 into "effective" capacity to treat concentrates. Many smelters have capacity in excess of their actual levels of production. The reasons for below-capacity operation are varied. In some cases smelters only operate when off-peak electric power is available. This occurs in some high cost electricity regions such as Europe and Japan. In other cases a smelter's capacity may be listed as its tank house capacity but it lacks adequate roasting or leaching capacity to fully utilize the tank house. In still other cases, various operating problems have consistently resulted in operating levels well below capacity. Minero Peru's Cajamarquilla smelter is an example of this latter point. Persistent power outages and general inefficiency have prevented this smelter from ever approaching its 102,000 tpy capacity.

We will examine capacity -vs- primary and secondary production by region and develop estimates of effective capacity to treat concentrates in 1994.

EUROPE

Belgium: Name plate capacity will hold at the current level of 315,000 tpy through 1994. Maximum slab production has been 300,000 and 30,000 of that was secondary. There is one dedicated secondary refiner with a capacity of 10,000 tpy. We will consider effective primary capacity (EPC) to be 280,000 tonnes in 1994.

Finland: Capacity will not change from the current level of 175,000 tpy. There is no secondary refined production. Production has reached capacity, so we will carry EPC in 1994 as 175,000 tonnes.

France: Capacity will not change from 315,000 tpy. Maximum production was 275,000 tonnes and 21,000 was secondary. We will use 255,000 tonnes as 1994 EPC.

Germany: Capacity has increased from 375,000 tpy in 1990 to 420,000 this year. Maximum production from plants operating in 1990 was 360,000 tonnes, of which 52,000 was secondary. Secondary production is likely to increase so that we will consider 1994 EPC to be 340,000 tpy.

Italy: Capacity will hold at the current level of 253,000 tpy. Maximum production was 248,000 tonnes. There is a dedicated secondary smelter with a capacity of 10,000 tpy. We will estimate 1994 EPC at 240,000 tpy.

Netherlands: Capacity will remain at 210,000 tpy through 1994. Production has run very close to that level and no secondary refined is reported. We will carry 1994 EPC at 210,000 tonnes.

Norway: Capacity will hold at 140,000 tpy through 1994. Production this year is running at a record level equal to an annual rate of 125,000 tonnes. There is a dedicated secondary refiner with a capacity of 10,000 tpy. We estimate 1994 EPC to be 135,000 tonnes.

Portugal: Capacity will increase from 11,000 to 24,000 tpy. Production had never exceeded 6,000 tonnes, but the plant has new owners (Inga) and operations are expected to be stepped up. We will use 20,000 tpy for EPC in 1994.

Spain: Capacity is being expanded from 286,000 tpy in 1990 to 368,000 tpy. Maximum production was 265,000 tonnes, of which

15,000 was secondary. There is a dedicated secondary refiner with a 6,000 tpy capacity. We estimate 1994 EPC at 350,000 tonnes.

United Kingdom: Capacity will increase from 95,000 tpy in 1990 to 105,000 tpy. Maximum production was 93,000 tonnes and no secondary refined production is reported, but domestic mine production and concentrate imports could not support reported slab production. Thus, we assume 10,000 tpy of secondary refined and we will carry 1994 EPC at 95,000 tonnes.

Yugoslavia: Capacity will remain at the current 120,000 tpy level. Production has approached this level, with secondary refined output of 5,000 tonnes. We will carry 1994 EPC at 115,000 tonnes.

1994 EUROPEAN PRIMARY EFFECTIVE CAPACITY

(000 tonnes)

COUNTRY	AMOUNT
Belgium	280
Finland	175
France	255
Germany	340
Italy	240
Netherlands	210
Norway	125
Portugal	20
Spain	350
UK	95
Yugoslavia	115
TOTAL:	2,205

ASIA

Japan: Name plate capacity is projected to increase from 837,000 tonnes in 1990 to 957,000 tonnes in 1994, although there is considerable uncertainty surrounding Japanese smelting plans as we have already discussed. A considerable amount of Japanese capacity exists only on paper -- it is not effective capacity. Maximum production has been 687,000 tonnes. Of that, 82,000 tonnes was secondary so that maximum primary production has been 605,000.

Plans are in place to increase recycling of steel mill flue dust so as to increase slab production from this source from 50,000 to 75,000 tpy. We expect total secondary production in 1994 to reach 105,000 tonnes.

Japanese plans are not to increase slab exports from the current 20,000 tpy level. It is not clear, however, how much slab zinc will be imported in the future. Imports have risen steadily to 141,000 tonnes last year.

We project Japanese consumption in 1994 at 900,000 tonnes. If imports fall back to 100,000 tonnes, exports remain at 20,000 and secondary production reached 105,000, there would be a need for 715,000 tonnes of primary slab production. On this basis we will carry 1994 EPC at 725,000 tonnes.

Korea: Capacity will rise from 255,000 tpy to 285,000 by 1993. Maximum production has been 248,000. No secondary slab production is reported. We will carry 1994 EPC at 270,000 tonnes.

India: Capacity will increase from 99,000 tpy in 1990 to 189,000 tonnes. Maximum production has been 79,000 tonnes. We will consider 1994 EPC to be 160,000 tonnes.

Thailand: Current capacity of 72,000 tpy will hold through 1994, although a new smelter is scheduled for startup at the end of 1994 or early 1995. Production has approached capacity so we will carry 1994 EPC at 72,000 tonnes.

Turkey: Capacity will increase modestly from 25,000 tpy in 1990 to 30,000 tpy. Production has approached capacity, so we will carry 1994 EPC at 30,000 tonnes.

1994 ASIAN PRIMARY EFFECTIVE CAPACITY
(000 tonnes)

COUNTRY	AMOUNT
Japan	725
Korea	270
India	160
Thailand	72
Turkey	30
TOTAL:	1,257

NORTH AMERICA

Canada: Canadian capacity will hold at the current level of 737,000 tpy through 1994. Maximum production has been 703,000 tonnes and no secondary refined production is reported. We estimate 1994 EPC at 705,000 tonnes.

United States: Capacity is not slated to change from the current level of 378,000 tpy. Maximum production has been 366,000 tonnes, with 96,000 as secondary. We estimated capacity at dedicated secondary refiners at about 20,000-25,000 tpy. We expect that secondary output will increase. We will carry 1994 EPC at 260,000 tonnes.

Mexico: Capacity will increase from 218,000 in 1990 to 293,000 tonnes. Maximum production has been 199,000 tonnes, of which 4,000 was secondary. We will carry 1994 EPC at 270,000 tonnes.

1994 NORTH AMERICAN EFFECTIVE PRIMARY CAPACITY
(000 tonnes)

COUNTRY	AMOUNT
Canada	705
United States	260
Mexico	270
TOTAL:	1235

LATIN AMERICA

Argentina: Capacity will remain at 33,000 tpy. Production has approached that level, so we will carry 1994 EPC at 33,000 tonnes.

Brazil: Capacity is projected to increase from 174,000 tpy in 1990 to 257,000 tpy. Production has run at close to capacity and no secondary refined output is reported. We will carry 1994 EPC at 240,000 tonnes.

Peru: Capacity is currently 171,000 tpy and while there is talk of an expansion it is very doubtful that any new capacity could be onstream by 1994. Maximum production has been 145,000 tonnes. Assuming that conditions improve somewhat by 1994 and power disruptions will be less common, we will estimate 1994 EPC at 150,000 tonnes.

1994 LATIN AMERICAN EFFECTIVE PRIMARY CAPACITY

(000 tonnes)

COUNTRY	AMOUNT
Argentina	33
Brazil	240
Peru	150
TOTAL:	423

AFRICA

Algeria: Capacity is not scheduled to increase from 30,000 tpy. Production has reached capacity, so that we will carry 1994 EPC at 30,000 tpy.

South Africa: Capacity is not scheduled to increase from 92,000 tpy. Production has hit that level so that we will carry 1994 EPC at 92,000.

Zaire: Capacity will not increase from the current level of 65,000 tpy. Maximum production was 61,000 tonnes, but with declining mine output, slab output has slipped. We will consider 1994 EPC to be 40,000 tonnes.

Zambia: Capacity will not increase from the current 25,000 tpy. Production was 21,000 tonnes in 1987 but fell to 11,000 last year. We will carry 1994 EPC at 12,000 tonnes.

1994 AFRICAN EFFECTIVE PRIMARY CAPACITY
(000 tonnes)

COUNTRY	AMOUNT
Algeria	30
South Africa	92
Zaire	40
Zambia	12
TOTAL:	174

AUSTRALIA

Capacity stands at 345,000 tonnes and there are presently no plans for any increases. Maximum recent production has been 312,000 tonnes and 2,000 of that was secondary. We will consider 1994 EPC to be 310,000 tonnes.

1994 NON-SOCIALIST WORLD EFFECTIVE PRIMARY CAPACITY
(000 tonnes)

COUNTRY	AMOUNT
Europe	2,205
Asia	1,257
North America	1,235
Latin America	423
Africa	174
Australia	310
TOTAL NON-SOCIALIST WORLD	5,604

We are now in a position to examine the concentrate/effective primary smelter capacity balance in 1994 and to determine how much additional primary smelter capacity will be needed by 2000. We must first adjust our mine production forecasts to put them on the same basis as our smelter capacity forecasts. Mine production is carried as the zinc content of concentrates. Smelter capacity is for slab zinc produced, not for the zinc content of concentrates treated.

There are metallurgical losses in converting concentrates to slab zinc. The percentage of zinc in concentrates actually recovered varies from smelter to smelter depending on the equipment employed, the composition of the concentrates and the efficiency of the operation. Well equipped and well run smelters can recover 96 percent of zinc in concentrate and some may even recover 97 percent. Some smelters do not have secondary leaching facilities and recover much less.

Rather than attempt to estimate what each smelter can recover, we have examined non-Socialist world production data over the last decade. We have taken mine production for each year and added or subtracted net East/West trade in concentrates to develop annual concentrate availability numbers. We then subtracted secondary refined production from total refined production to develop primary refined numbers. We then calculated primary refined production as a percentage of concentrate availability. There were year-to-year variations, but these can be explained by concentrate stock buildups and drawdowns at the smelters. The average for the decade was 94 percent and most years were close to that. We believe this recovery rate will gradually improve as older plants are modernized or replaced by new plants. Thus, our projected recovery rate edges up to 94.8 percent by 2000.

Before applying the recovery rate we must adjust annual mine production to incorporate our assumption of East/West trade in concentrates. The East Bloc was a significant net importer of concentrates through most of the 1980s. Net imports reached 176,000 tonnes in 1984 but then began to fall off. By 1990 they had fallen to 42,000 tonnes and so for this year both imports and exports are down sharply and are about balanced.

Our understanding is that most Eastern European zinc mines are very high cost and will not survive the transformation to a market economy. We also expect a contraction in smelter capacity through the combination of lost local concentrate feed and a tightening of environmental regulations. Thus, we are projecting that through 1995 East Bloc imports and exports of concentrates will be fairly insignificant and roughly in balance.

Over the second half of the decade we expect that Eastern Europe's economic restructuring will begin to produce results and that zinc consumption will rise. We expect that new smelter capacity will be built to meet some of the increased demand, but we doubt that local mine production will increase. Thus, we expect that Eastern Europe will once again become a net importer of Western World zinc concentrate. We project that East Bloc net imports will rise from 40,000 tonnes in 1996 to 150,000 in 2000.

We must also deduct a very small tonnage (4,000 tpy) from concentrate availability to account for American Process zinc oxide production (i.e., oxide produced directly from concentrate).

This produces the following balance of Western World primary raw material supply from 1994 to 2000 and the 1994 effective primary smelter capacity (000 tonnes).

WESTERN WORLD PRIMARY SMELTER BALANCE
(000 tonnes)

	1994	1995	1996	1997	1998	1999	2000
Concentrate Production	5756	5820	5943	6071	6222	6431	6619
East Bloc Net Imports (-)	---	---	40	60	80	120	150
Direct-Use Oxide (-)	4	4	4	4	4	4	4
Western Concentrate Supply	5752	5816	5899	6007	6138	6307	6465
Recoverable Zinc	5407	5467	5568	5683	5814	6001	6128
1994 Effective Primary Capacity	5604	5604	5604	5604	5604	5604	5604
Smelter Capacity Surplus (+) Deficit (-)	+197	+137	+36	-79	-210	-397	-524

This analysis would indicate that the smelter capacity additions scheduled through 1994 would be adequate to handle 1995 concentrate supply as well. However, it must be remembered that our calculation of effective primary capacity is based on the maximum production levels achieved by each smelter. These peak production performances were not all registered in the same year and, indeed, it is extremely unlikely that this would ever happen. Thus, there must be some surplus capacity available to assure that all of the concentrates produced each year can be treated.

To put this into perspective, there will be 58 primary zinc smelters operating in 1994. If half of them match their peak performance that year and the other half produce 5,000 tonnes less than their best effort, production would be 145,000 tonnes less than our calculation of effective primary capacity. Thus, we would not consider the calculated surpluses in 1994 and 1995 to be a problem. A safety margin of 150,000 to 200,000 tonnes could easily be needed to assure that all concentrates can be treated.

A second point worth noting is that adequate smelter capacity on a world-wide basis does not guarantee that all concentrates can be smelted. Some smelters are dedicated to treating the output of local mines. Should local mine production decline for any reason, many of these smelters would not be able to economically buy in substitute feed. The most obvious example of this would be the smelters in Zambia and Zaire. We will deal with the regional balances in the next section of this report.

A third important point to consider is that in our base case forecast we have assumed that the Eastern Bloc would again become a net importer of Western slab zinc in the 1996-2000 period. (We have already explained our view of resumed net imports of concentrates by East Bloc countries over 1996-2000.)

East Bloc net imports of metal rose sharply from 64,000 tonnes in 1981 to 250,000 in 1985. Thereafter, they slipped back to about 40,000 tpy through 1989. The collapse of the Soviet and Eastern European economies in 1990 crushed domestic demand and freed up zinc for export to the West. The East Bloc became a net exporter of 39,000 tonnes in 1990 and we are projecting net exports of 80,000 tonnes this year. We believe the combination of the closure of economical mines and environmentally unsound smelters, along with a gradual recovery in consumption will result in a reduction of net East Bloc exports to 60,000 tonnes in 1992 and 30,000 in 1993. In 1994 and 1995 we are assuming balanced trade in slab. We believe that economic restructuring will begin to show results over the second half of the decade and zinc consumption will begin to rise steadily. We have assumed that some of this increased demand would be met through new East Bloc smelter capacity based on Western concentrates. We believe that part of it would also be met by increased imports of Western slab zinc. We project that net East Bloc imports of zinc metal will rise from 20,000 tonnes in 1990 to 100,000 in 2000.

Obviously, such forecasts are highly speculative at this juncture. The point of concern here is that increased East Bloc demand for Western slab zinc must be based on increased Western smelter capacity over the second half of the decade. We believe our forecast of East Bloc net imports is conservative. We believe there is more upside risk to our 100,000 tonne projection for 2000 than there is downside risk.

Thus, our projection of 524,000 tonnes of needed new smelter capacity could reasonably be increased to account for:

1. **A needed safety margin of 150,000 - 200,000 tonnes,**
2. **The prospect of East Bloc net imports exceeding 100,000 tonnes.**

There could easily be a need for as much as 750,000 - 800,000 tonnes of new capacity between 1994 and 2000.

As we previously mentioned, one new smelter project has already been announced for the 1995-2000 period. A partnership of Thailand's Padaeng Co. and Germany's Metallgesellschaft -- named Southeast Asia Metal Co. -- has announced a new ISF in Thailand with a capacity of 60,000 tpy of zinc and 40,000 tpy of lead. Startup is projected for the beginning of 1995.

There are some other smelter projects under study. We will merely mention them here, but will explain them in more detail in the next chapter. They include:

__Indonesia__: Both a copper smelter and a zinc smelter are under study. Both studies assume that the smelters would be tied into a phosphate fertilizer plant, thereby providing the project with a good sulfuric acid market. The zinc smelter would probably be tied into development of the giant Century mine in Australia. It is not clear whether both smelters could be developed, considering the link with the fertilizer plant.

__Japan__: We have already discussed the situation in Japan through 1994. It seems likely that over the 1995-2000 period domestic capacity could be increased to match growth in demand. Older and higher cost capacity would most likely be replaced by newer and larger capacity.

__Australia__: It is possible but unlikely that a new smelter could be built in Queensland when Century is developed. One of the biggest drawbacks to such a smelter is that sulfuric acid would have to be shipped great distances to market, resulting in little if any sulfur credit. This would seriously affect the economics of the project.

A further expansion of the Risdon smelter has been considered for some time, however, we do not consider this expansion likely. Pasminco has severe financial problems that seem likely to persist. Furthermore, it is very expensive to ship concentrates by vessel from one part of Australia to another because of laws aimed to benefit local shippers and dock workers. It is cheaper to ship from Queensland to Europe than to Tasmania.

France: The French state-owned electricity company -- EDF -- is actively seeking investment by energy intensive industries and will offer very attractive power rates. We know that some companies are looking into a new French smelter, but we have not identified the interested parties.

Brazil: We have included the expansion of Inga's smelter in our base case. Both CMM and Paraibuna are considering expanding their smelters as well. There is currently more than enough capacity to meet domestic demand and the Inga expansion will easily cover growth through 1995. We do not consider it likely that new capacity would be based on the premise of imported concentrates and exported metal. However, strong domestic demand growth in the second half of the decade could support additional smelter capacity.

Korea: At present Korea produces more zinc than it consumes and the Onsan smelter is being expanded by 30,000 tonnes. However, Korean zinc consumption has been growing very rapidly and if the national goal is self-sufficiency in zinc metal, more capacity would be needed in the second half of the decade. We consider a further expansion of Onsan more likely than a new greenfield smelter.

Peru: Minero Peru has stated that it would like to expand its 102,000 tpy Cajamarquilla smelter. However, power shortages and other operating problems have held production well below capacity. Talk of an expansion, considering current conditions in Peru, seems ridiculous. Should stability return to Peru a few years down the road, an expansion could then attract serious attention. Thus, this is a possible project for the second half of the decade.

Spain: Asturiana is undergoing a major expansion from 200,000 to 300,000 tpy. This will make it far and away the largest zinc smelter in Europe. Costs are very competitive and this makes Asturiana a candidate for even further expansion in the second half of the decade.

Canada: Both Trail and Valleyfield have long been considered likely candidates for expansion. Both Cominco and Noranda have surplus concentrates, but some of their major mines face ore depletion by 2000. To date, neither company has determined that the cost of expansion can be justified, although Cominco would probably have proceeded had it secured a favorable water tax for hyproelectricity generation from the British Columbian government. We consider prospects more favorable for a Trail expansion than for a Valleyfield expansion in the second half of the decade.

Before making any judgements as to which projects appear most likely, let us examine the regional consumption/mine production/smelter capacity balances to see where new capacity would most logically be located. In subsequent chapters we will examine projected costs and revenues of several potential expansions and greenfield smelters.

I.6 Regional Balance Forecast

In this section we will estimate the regional balances of primary zinc demand, zinc mine production and 1994 effective primary smelter capacity. The numbers that have been developed earlier in this chapter must be adjusted and rearranged for the purpose of this analysis. We will use the regional grouping developed in our projection of demand. We must apportion our non-Socialist world forecast of secondary refined production to specific regions so that refined zinc consumption forecasts can be converted to primary refined zinc forecasts.

A considerable tonnage of secondary zinc is recovered that is not re-refined. Zinc scrap that is simply remelted, either in the form of pure zinc or as the zinc content of brass or other copper alloys, is not included in our tabulation of production or consumption. The amount of zinc recovered through remelting in 1980 was 1,264,000 tonnes, compared with 334,000 tonnes that was re-refined. Thus, total zinc consumption is nearly 1 mn tonnes more than refined zinc consumption.

On the supply side, we must estimate which regions will be shipping concentrates and slab zinc to the East Bloc and which regions will be receiving concentrates and slab zinc from the East Bloc. The net trade numbers presented earlier will not be adequate for this regional analysis, since one region could be a supplier of zinc to the East Bloc while another could be a customer for East Bloc zinc.

I.6.1 Regional Primary Consumption Forecast

We are projecting that secondary refined zinc production will increase by 35 percent over the decade from 334,000 in 1990 to 450,000 in 2000. The reason for this strong rate of growth lies in the increased recycling of steel mill electric arc flue dust which is captured when galvanized steel is melted. Traditionally this flue dust was disposed of in land fills since the zinc content was considered too low for economical recovery.

However, it was found that the zinc could leach out of the dust and end up in groundwater, lakes or rivers. Consequently, legislation has been enacted strictly regulating the disposal of this flue dust. Faced with alternatives of enpoundment in toxic waste dumps or treatment of the dust to remove the zinc, most steel mills are opting for zinc removal and recycling into a useable zinc raw material.

Japan is the most advanced in recycling flue dust. Presently about 300,000 tpy are treated to recover 50,000 tpy of zinc. By 1995 the entire 450,000 tonnes of flue dust created that year will be recycled to produce 75,000 tonnes of zinc. This should lift total Japanese secondary refined zinc production to 107,000 tonnes by 1995. Thereafter, the growth will slow to approximate the growth in the tonnage of galvanized steel and other zinc containing products recycled each year. We project secondary refined zinc production of 118,000 tonnes in 2000.

We project that European secondary refined zinc production will increase by 20,000 tonnes from 1990 to 1995 to reach 170,000 tonnes. We expect a similar increase over 1995-2000 so that secondary refined zinc output will reach 190,000 tonnes in 2000.

We look for a similar pattern in the US, with production increasing from 96,000 tonnes in 1990 to 114,000 in 1995 and 136,000 in 2000.

Secondary refined zinc production outside the three highly industrialized regions is minimal. We do not believe that the tonnage of galvanized steel recycled in other regions will economically justify the investment in flue dust treatment facilities.

Thus, we project that non-Socialist world production of secondary refined zinc will increase from 334,000 tonnes in 1990 to 397,000 in 1995 and 450,000 in 2000.

The following table converts our regional zinc consumption forecast into a forecast of primary zinc consumption by deleting secondary refined production. To redefine the groupings, North America includes Mexico, Europe is just Western Europe, Australasia includes Australia, New Zealand, India, Japan and other East Asian countries, Africa/Mideast includes West Asian countries (i.e., the Arab states, Israel, Turkey, Iran, etc).

WESTERN WORLD REGIONAL PRIMARY ZINC CONSUMPTION
(000 tonnes)

	1995	1996	1997	1998	1999	2000
North America						
Total	1364	1368	1384	1403	1440	1469
Secondary	118	123	127	132	136	140
Primary	1246	1245	1257	1271	1304	1329
Europe						
Total	2057	2081	2115	2151	2178	2202
Secondary	170	175	179	183	187	190
Primary	1887	1906	1936	1968	1991	2012
Australasia						
Total	1906	1945	2009	2074	2141	2172
Secondary	109	111	114	116	118	120
Primary	1797	1834	1894	1958	2023	2052
South America						
Primary	275	285	295	305	320	330
Africa/Middle East						
Primary	282	285	288	292	298	305
Non-Socialist World						
Total	5884	5964	6091	6224	6374	6480
Secondary	397	409	420	431	441	450
Primary	5487	5555	5671	5793	5933	6030

I.6.2 East/West Trade In Concentrates and Metal

Let us now turn to East/West trade in zinc concentrates and metal. We project that the East Bloc will re-emerge as a net importer of concentrates in 1996. Our annual projections are as follows:

CONCENTRATE NET IMPORTS TO EASTERN BLOC
(000 tonnes)

YEAR	AMOUNT
1996	40
1997	60
1998	80
1999	120
2000	150

We assume that China will be an exporter of 35,000 tpy over the 1995-2000 period, with all of this going to Far Eastern smelters. Thus, concentrate supply in the Australasian region will be 35,000 tonnes more than local mine production.

Total East Bloc imports would increase from 35,000 tonnes in 1995 to 185,000 in 2000. We assume Eastern Europe and the Soviet Union will be the importers. The main concentrate shippers to Eastern Europe in the past have been Europe (mainly Sweden, Spain and Greece), Canada and Peru. Australia does not report any exports to communist countries, but it carries a fairly large tonnage in a "country unspecified" category and some of that could be sent to the USSR and Eastern Europe.

CONCENTRATE EXPORTS TO EASTERN BLOC

(000 tonnes)

	1995	1996	1997	1998	1999	2000
Europe	15	30	35	35	40	40
Canada	10	20	30	35	45	50
Peru	---	10	10	10	15	20
Australia	---	15	20	35	50	75
TOTAL:	35	75	95	115	155	185

We will reduce our regional mine production projections by these amounts to come up with numbers representing concentrate supplies available for non-Socialist world smelters.

SLAB ZINC NET EXPORTS FROM EASTERN BLOC

(000 tonnes)

YEAR	AMOUNT
1995	----
1996	20
1997	40
1998	60
1999	80
2000	100

We assume that over this period North Korea will maintain exports of 50,000 tpy and China of 20,000 tpy. This would all go to the Far East, i.e. Japan, India, Hong Kong, etc. We will deduct this tonnage from Australasian projected consumption to develop figures representing Australasian demand for Western World refined zinc.

We believe that East Bloc slab imports will all go to Eastern Europe and the USSR and that all of it will come from Western European smelters. Thus, we will add the following tonnages to our European consumption forecasts to produce figures representing total demand for metal from Western World smelters.

SLAB ZINC NET IMPORTS TO WEST
(000 tonnes)

YEAR	AMOUNT
1995	70
1996	90
1997	110
1998	130
1999	150
2000	170

Next, a discussion of the projected balances in the five geographical groupings is presented.

I.6.3 North America

We have decided to include Mexico with the US and Canada rather than with the other Latin American countries for two reasons. First, the US is the closest market for Mexican exports and, second, the planned North American free trade zone will likely draw these three countries closer together in terms of zinc trade.

Consumption in the region is projected to grow at an annual average rate of 1.4 percent over the six year period of 1995 - 2000. Because of rising secondary production due to increased recycling of steel mill flue dust, our projection of average growth in primary zinc consumption is slightly lower at 1.3 percent.

Mine capacity is projected to decline from 2.62 Mn tonnes in 1995 to 2.47 Mn tonnes in 2000, reflecting the depletion of such major Canadian mines as Sullivan and Polaris. Mine production would fall from 2.36 Mn tonnes in 1995 to 2.26 Mn in 2000. With our assumption that Canadian concentrate exports to the East Bloc would rise from 10,000 tonnes in 1995 to 50,000 in 2000, concentrate availability for Western smelters would decline from 2.35 Mn tonnes in 1995 to 2.24 Mn in 2000. The recoverable zinc equivalents would be 2.21 Mn in 1995 and 2.1 Mn in 2000.

Effective primary smelter capacity in 1994 is estimated at 1,235,000 tpy. Thus, the exportable concentrate surplus for the region -- in terms of recoverable zinc -- would fall from 970,000 tonnes in 1995 to 860,000 in 2000.

The surplus of recoverable zinc in concentrates available for Western smelters over North American primary consumption would decline from 959,000 tonnes in 1995 to 766,000 in 2000. This would reflect rising consumption, lower mine output and increased concentrate exports to the East Bloc.

However, these overall regional balances are somewhat misleading. Some Western Canadian mines and the Red Dog mine in Alaska export concentrates in the Far East more economically than they could ship to US or Eastern Canadian smelters. Cominco's Trail smelter in British Columbia is the only North American smelter in the region. Once Cominco's Sullivan mine is depleted at end of the decade the expectation is that more Red Dog concentrates will go to Trail and less will be exported from North America.

Eastern Canada would have an estimated effective primary smelter capacity of 426,000 tpy in 1994 against a mine capacity of 938,000 tonnes. Mine closures would reduce Eastern Canadian mine capacity to 598,000 tpy by 2000. New mine development could bring capacity back up to about 750,000 tpy. Thus, while Eastern Canada's concentrate surplus would likely decline, there would still be adequate concentrates to support additional smelter capacity.

We should add that there is considerable uncertainty inherent in estimating mine capacity out to 2000. Some of the mines that would be depleted by 2000 based on currently proven ore reserves will probably be extended through the discovery of additional ore reserves. Furthermore, it is likely that some ore bodies that have not yet been discovered will be in production by 2000. Thus, we can only try to assess the trend. We believe that there will be a lower level of mine production in Eastern Canada in 2000 than in 1995, but that mine output will still be well in excess of 1994 smelter capacity.

Perhaps of more importance than the balance of mine production and smelter capacity is the balance of primary zinc consumption and primary smelter capacity. Our tabulation shows that 1994 effective primary smelter capacity of 1,235,000 tonnes would be only 11,000 tonnes less than North American primary zinc consumption and that by 2000 this would increase to 94,000 tonnes.

Thus, if all of the slab zinc produced in North America were consumed in North America, there would be an import need of only about 94,000 tonnes in 2000. In other words, if 100,000 tpy of new smelter capacity were developed, North America could be self sufficient in slab zinc.

In 1990, Canada exported 450,000 tonnes of slab. Of that 373,000 went to the US and 77,000 went out of North America. In 1990, Mexico exported 92,000 tonnes of slab, with about 72,000 tonnes going to the US and 20,000 going out of North America. In 1990, the US imported 601,000 tonnes of slab, with 344,000 from Canada, 72,000 from Mexico and 185,000 from outside of North America. Thus, exports out of North America were 97,000 tonnes and imports from outside of North America were 185,000 tonnes, for a net import total of 88,000 tonnes.

Should the US/Canada/Mexico free trade zone develop, it could result in a decrease in Canadian and Mexican exports outside of North America and a consequent reduction in US imports from outside of North America.

Thus, we believe it would be prudent to evaluate the need for new smelter capacity in North America based on North American demand for slab zinc rather than the availability of concentrates. Both Europe and Japan have tariff structures that allow their smelters to bring in concentrates free while imposing a duty on slab imports. Unless this tariff wall is removed, it will be difficult for North American producers to switch from exporting concentrates to exporting slab zinc. Consequently, in the absence of a removal of slab zinc tariffs, North American smelters must consider the North American market alone when evaluating the viability of new smelter capacity.

The following table sets out our projections of the North American market balance from 1995 to 2000.

NORTH AMERICAN REFINED ZINC BALANCE
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Total Consumption	1364	1368	1384	1403	1440	1469
Secondary Production (-)	118	123	127	132	136	140
Primary Consumption	1246	1245	1257	1271	1304	1329
Mine Capacity	2620	2600	2526	2558	2418	2471
Mine Production	2356	2345	2283	2321	2200	2260
Concentrate Exports to East Bloc (-)	10	20	30	35	45	50
Concentrates Available for Western Smelters	2346	2325	2253	2286	2155	2210
Recoverable Zinc	2205	2194	2131	2166	2050	2095
Effective Primary Smelter Capacity - 1994	1235	1235	1235	1235	1235	1235
Concentrate Surplus	970	959	896	931	815	860
Deficit Smelter Capacity to Primary Demand	11	10	22	36	69	94
Surplus Recoverable Zinc to Primary Consumption	959	949	874	895	746	766

I.6.4 Europe

Consumption in Europe is projected to increase at an annual average rate of 1.5 percent. Because of an expected increase in secondary slab production from recycled steel mill flue dust, the growth in primary zinc production is projected to expand at a slightly lower rate of 1.37 percent per year. However, we believe that European smelters will benefit from increasing exports to Eastern Europe and the USSR over the second half of this decade so that total demand -- domestic consumption plus East Bloc exports -- would increase by an average rate of 2.1 percent per year.

Mine capacity is projected to increase from 879,000 tonnes in 1995 to 1,009,000 in 2000, while mine production would rise from 804,000 tonnes to 940,000. We also expect that European concentrate exports to Eastern Europe and the USSR will rise from 15,000 to 40,000 tonnes from 1995 to 2000. While Europe is a large importer of zinc concentrates we believe that logistical considerations would favor exporting some concentrates to Eastern Europe even though this would have to be offset by increased concentrate imports from other countries.

Thus, European concentrate supplies available for European smelters would increase by less than the increase in mine production over the 1995-2000 period -- 111,000 tonnes as against 136,000 tonnes. In terms of recoverable zinc, local supplies for European smelters would increase from 742,000 tonnes to 853,000.

We estimate effective primary smelter capacity in 1994 at 2,205,000 tonnes. In the absence of any new smelter capacity, the need for concentrate imports (recoverable zinc) would fall by about 100,000 tonnes -- from 1,463,000 to 1,352,000.

It is particularly interesting to note that 1994 effective primary capacity would be just about able to meet total demand (i.e., domestic consumption and exports to the East Bloc, in 2000). The smelter capacity surplus over total demand would be 248,000 in 1995 and would gradually shrink to 23,000 by 2000.

European slab exports to other Western countries usually run at about 250,000 tonnes, with about 150,000 to the US and 100,000 elsewhere -- mainly to Africa and the Middle East. (US imports from Europe were under 100,000 tonnes in 1990 because of the recession.)

Thus, any new smelter capacity in Europe would in large part be predicated on the assumption that slab export could be sustained. We have already noted that the North American free trade agreement could result in greater Canadian and Mexican exports to the US, with a consequent reduction in US demand for European slab. Any increase in North American smelter capacity in the 1995 - 2000 period would also be aimed at the US market and would further reduce US demand for European metal.

Thus, it is our view that European smelters should anticipate the loss of much of their US market over the 1995-2000 period. Exports to Africa, the Middle East and elsewhere could grow modestly from the recent 100,000 tpy level.

Consequently, we believe European smelter capacity should not exceed domestic demand and East Bloc export demand by more than 150,000 tonnes. That would mean that only about 150,000 tonnes of new smelter capacity would be needed around 1998-1999. However, should demand from Eastern Europe and the USSR expand by more than we have projected (170,000 tonnes by 2000), then additional smelter capacity could be accommodated.

EUROPEAN REFINED ZINC BALANCE
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Total Consumption	2057	2081	2115	2151	2178	2202
Secondary Production (-)	170	175	179	183	187	190
	----	----	----	----	----	----
Primary Consumption	1887	1906	1936	1968	1991	2012
Slab Exports to East Bloc (+)	70	90	110	130	150	170
	----	----	----	----	----	----
Total Demand	1957	1996	2046	2098	2141	2182
Mine Capacity	879	883	892	902	969	1009
Mine Production	804	812	821	835	903	940
Concentrate Exports to East Bloc (-)	15	30	35	35	40	40
	----	----	----	----	----	----
Concentrates Available for European Smelters	789	782	786	800	863	900
Recoverable Zinc	742	738	744	758	821	853
Effective Primary Smelter Capacity - 1994	2205	2205	2205	2205	2205	2205
Need for Recoverable Zinc in Concentrate Imports	1463	1467	1461	1447	1384	1352
Surplus Smelter Capacity Over Total Demand	248	209	159	107	64	23

I.6.5 Australasia

We are quite bullish on the prospects for demand growth in the emerging economies of Asia. Many Asian countries will be passing through the basic infrastructure stage of economic development and this phase has a high intensity of use for galvanized steel. We are projecting an annual average growth rate for primary zinc consumption of 2.6 percent.

We are projecting that North Korea and China will sustain slab zinc exports to the region of about 70,000 tpy. Demand for slab zinc from Western World smelters would increase from 1,727,000 tonnes in 1995 to 1,982,000 in 2000. We are projecting modest growth in secondary refined production and consumption from 109,000 tonnes in 1995 to 120,000 in 2000. This modest growth is based on the assumption that Japan will already be recycling all of the steel mill flue dust created each year by 1995.

We believe that Australia will account for a disproportionate share of the world's new mine capacity over the 1995 - 2000 period. Three potential mines in northern Queensland -- Century, McArthur River and Dugald River -- could produce over 650,000 tpy of zinc. We are projecting that Australasian mine capacity will increase from 1,491,000 tonnes in 1995 to 2,177,000 in 2000 and that mine production will rise from 1,359,000 to 2,027,000 over the same period. We expect Chinese concentrate exports to hold at about 35,000 tpy, while Australian concentrate exports to the East Bloc will develop over the period and reach 75,000 tonnes by 2000. Thus, concentrate supplies available for Western smelters would increase from 1,394,000 tonnes in 1995 to 1,987,000 in 2000. On the basis of recoverable zinc, the increase would be from 1,310,000 tonnes to 1,883,000.

Effective primary zinc smelter capacity at year-end 1994 is projected at 1,537,000 tonnes. Without any new capacity thereafter, the region would have a concentrate deficit of 227,000 tonnes in 1995. This would fall to 130,000 tonnes in 1996 and thereafter a steadily rising concentrate surplus would arise. By 2000 the surplus would reach 346,000 tonnes. A new ISF smelter has been announced in Thailand which could start up at the beginning of 1995. Should this project proceed, the concentrate deficit would be 60,000 tonnes larger in 1995 and the surplus that much smaller after 1988.

Without any new smelter capacity after 1994 the regional deficit of smelter capacity to total demand would rise to 190,000 tonnes in 1995 to 445,000 in 2000. With the new Thai smelter the deficit would increase from 130,000 to 385,000 tonnes.

We have also calculated the relationship of recoverable zinc in available regional concentrates to demand for zinc from Western World smelters. The deficit would be 417,000 tonnes in 1995, but with the huge increase in mine capacity it would shrink to 99,000 tonnes in 2000. In other words, if adequate smelter capacity were built to meet total regional demand, concentrate imports would provide only about 100,000 tonnes of the feed for the capacity. Domestic concentrate supply -- even assuming exports to the East Bloc of 75,000 tonnes -- would reach 1,883,000 tonnes (recoverable zinc) in 2000, against a demand for slab of 1,982,000 tonnes.

We believe that chances are very good that enough new capacity will be built so that the region does not become a net concentrate exporter. As noted above, if the Thai ISF goes ahead, the concentrate surplus over smelter capacity would be only 286,000 tonnes. A new smelter is under study in Indonesia, while Japanese capacity will be expanded to match demand growth. Korea is another likely candidate for expansion.

If the region were to continue to import some 300,000 tonnes of recoverable zinc in concentrates while treating all of its own concentrates it would need almost 600,000 tonnes of capacity in addition to the Thailand ISF. However, if this took place, our forecast indicates that the region would produce some 200,000 tonnes more zinc in 2000 than it could consume. This is highly unlikely. What would be much more likely would be a reduction in concentrate imports to closer to 100,000 tpy. This would mean that with 386,000 tonnes of new smelter capacity the region would be balanced in slab zinc production and consumption.

The actual numbers will undoubtedly be somewhat different as events unfold, but we believe this will be the trend. We believe smelter capacity will be built in Australasia so that the region will not become an exporter of concentrates. And, as a result of the major expansions projected for regional mine production, we expect that zinc concentrate imports from North and South America are likely to decline.

AUSTRALASIAN REFINED ZINC BALANCE
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Total Consumption	1906	1945	2009	2074	2141	2172
Secondary Production (-)	109	111	114	116	118	120
	----	----	----	----	----	----
Primary Consumption	1797	1834	1895	1950	2023	2052
Slab Imports from East Bloc (-)	70	70	70	70	70	70
	----	----	----	----	----	----
Demand for Western Slab	1727	1764	1825	1888	1953	1982
Mine Capacity	1491	1604	1771	1865	2088	2177
Mine Production	1359	1471	1627	1715	1925	2027
Concentrate Imports from East Bloc (+)	35	35	35	35	35	35
Concentrate Exports to East Bloc (-)	--	15	20	35	50	75
	----	----	----	----	----	----
Concentrates Available for Western Smelters	1394	1491	1642	1715	1909	1987
Recoverable Zinc	1310	1407	1553	1625	1816	1883
Effective Primary Smelter Capacity - 1994	1537	1537	1537	1537	1537	1537
Concentrate Deficit	227	130				
Concentrate Surplus			16	88	279	346
Deficit Smelter Capacity to Total Demand	190	227	288	351	416	445
Deficit Recoverable Zinc to Total Demand	417	357	272	263	137	99

I.6.6 Africa/Middle East

In this grouping we include the western Asian countries, i.e. the Arab states, Israel, Turkey and Iran. In terms of mine production, the only Asian producers in this grouping are Turkey, Iran and Saudi Arabia.

In 1990 this region consumed 276,000 tonnes of slab zinc, all of which was primary. The African countries consumed 156,000 tonnes, with South Africa accounting for 87,000 of that. The Near East consumed 120,000 tonnes, with half of that in Turkey. While there is clearly potential for strong zinc consumption growth in this largely undeveloped region, we are not very optimistic. The political stability necessary for economic growth has been lacking in most of these countries and we see no reason to assume this will change. We are predicting an average consumption growth rate over the 1995-2000 period of only 1.4 percent.

Mine capacity in the region will increase from 378,000 tonnes in 1990 to 503,000 in 1995. The increases will come from Morocco (49,000 tonnes), Tunisia (70,000) and Turkey (35,000). We are projecting mine capacity growth from 503,000 in 1995 to 569,000 in 2000. Capacity utilization rates have been quite low in many of these countries and we are projecting that mine production will increase from 424,000 tonnes in 1995 to 490,000 in 2000. In terms of recoverable zinc this equates to 399,000 tonnes in 1995 and 464,000 in 2000.

Effective primary smelter capacity in 1994 is projected at 204,000 tonnes. In the absence of any new capacity, the region's concentrate surplus would increase from 195,000 tonnes in 1995 to

260,000 in 2000. The deficit of smelter capacity to consumption would rise from 78,000 tonnes in 1995 to 101,000 in 2000.

Thus, the region has mine production in excess of consumption, but metal production less than consumption. On the surface this would point toward the likelihood of additional smelter capacity. However, except for South Africa, the countries with the mine production are not major consumers. Furthermore, the region is so widespread and diverse that there would be little, if any, locational advantage for a regional smelter. There will be enough mine production in Morocco and Tunisia to support a joint smelter, but this mine production has been earmarked for existing European smelters and we are not aware of any consideration being given to a new North African smelter.

AFRICA/MIDDLE EAST REFINED ZINC BALANCE
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Primary Consumption	282	285	288	292	298	305
Mine Capacity	503	531	562	557	572	569
Mine Production	424	448	474	470	494	490
Recoverable Zinc	399	423	448	445	470	464
Effective Primary Smelter Capacity - 1994	204	204	204	204	204	204
Concentrate Surplus	195	219	244	241	266	260
Deficit Smelter Capacity to Consumption	78	81	84	88	94	101

I.6.7 South America

Zinc consumption has fallen sharply in this region in recent years due to economic crisis in Brazil, Argentina and

Peru. Consumption fell from 336,000 tonnes in 1987 to 265,000 in 1990. We project that demand will fall to 235,000 tonnes this year. We expect a recovery to commence in 1992 and over the 1995-2000 period we expect growth to average 3.7 percent per year. However, even with this strong a growth rate there would be no real increase from 1987 to 2000.

We project a growth in mine capacity from 1,049,000 tonnes in 1995 to 1,082,000 in 2000 and a growth in mine output from 877,000 to 920,000. In terms of recoverable zinc this would equate to an increase from 824,000 tonnes to 872,000.

Primary smelter capacity in 1994 is projected at 423,000 tonnes. This assumes that the planned expansion by Inga in Brazil from 54,000 tpy to 110,000 tpy goes ahead as scheduled. This would lift Brazilian smelter capacity to 257,000 tonnes. CMM is also considering an expansion of its Tres Marias smelter. If that goes ahead, Brazil would become an exporter of perhaps as much as 150,000 tpy of slab. This would have to be exported out of the region.

Minero Peru is also considering an expansion of its Cajamarquilla refinery, which would result in a decrease in concentrate exports.

Where exactly these producers think they will be able to sell their slab production is not clear. We have noted that (1) North America could well be self sufficient in slab zinc with only 100,000 tpy of additional smelter capacity, (2) Australasia will be close to self sufficient if it matches its growth in mine output with new smelter capacity and, (3) Europe has smelter capacity in excess of domestic consumption.

In the absence of any additional smelter capacity, the South American surplus of zinc concentrate supply over smelter capacity would increase from 401,000 tonnes in 1995 to 449,000 in 2000.

The surplus of smelter capacity to consumption would decline from 148,000 tonnes in 1995 to 93,000 in 2000.

SOUTH AMERICAN REFINED ZINC BALANCE
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Primary Consumption	275	285	295	305	320	330
Mine Capacity	1049	1037	1036	1042	1071	1082
Mine Production	877	867	866	881	910	920
Recoverable Zinc	824	818	819	835	866	872
Effective Primary Smelter Capacity - 1994	423	423	423	423	423	423
Concentrate Surplus	401	395	396	412	443	449
Surplus Smelter Capacity to Consumption	148	138	128	118	103	93

I.7 Conclusions

The major change in the structure of the zinc market that we see developing over the second half of the decade is that Australasia's mine production will expand so dramatically that the region will have the potential for virtual self-sufficiency. If all of this mine production were smelted within the region, slab zinc production from local concentrates would come within

100,000 tonnes of Australasian slab zinc demand by the year 2000. This assumes a small net export trade in concentrates of 40,000 tonnes to the East Bloc and net imports of East Bloc metal of 70,000 tonnes.

By contrast, our forecasts show that in 1995 Australasia will have a net import need of 227,000 tonnes of zinc in concentrates and 190,000 tonnes of slab zinc.

In North America, the establishment of a US/Canada/Mexico free trade zone would encourage increased sale of Canadian and Mexican slab to the US at the expense of European exports to the US. In 1995, North American smelter capacity would be close to slab zinc demand. An additional 150,000 tonnes of smelter capacity would probably be enough to assure regional self-sufficiency by 2000.

In Europe, the surplus of smelter capacity to domestic demand plus slab exports to Eastern Europe would disappear late in the decade if no new smelter capacity were added after 1994. The need for imported concentrates to support the 1994 level of smelter capacity would decline by 100,000 tonnes over the second half of the decade but would remain very large at 1,352,000.

As we noted earlier in this chapter, about 750,000 tonnes of new smelter capacity would be needed over the 1995 - 2000 period to meet the growth in Western World demand, to supply net exports of slab to the Eastern Bloc of 150,000 tonnes by 2000 and to provide some margin of safety to cover smelter production disruptions.

While it is impossible to state with a high degree of certainty where this new capacity would be built, we can draw some conclusions from our regional balance analysis as to where one would most logically expect it to be built. These are our conclusions.

Australasia: This region would have the mine supply and the slab zinc demand to support a major amount of new capacity. We believe it is reasonable to assume that the region would not be exporting concentrates when this would simply increase its need for slab imports.

About 400,000 tonnes of new smelter capacity would be needed by 2000 to treat all of the region's concentrate supply. This would leave a need for about 100,000 tonnes of slab imports. Of course, it would also be possible to build 500,000 tonnes of new smelter capacity, import 100,000 tonnes of zinc in concentrates and not import any slab.

North America: Since the region is an exporter of concentrates and an importer of metal, it would be logical to expect a move toward slab self-sufficiency. A successfully enacted US/Canada/Mexico free trade agreement would make this even more logical. To achieve self-sufficiency, about 150,000 tonnes of new smelter capacity would be needed by 2000.

Logistical consideration would tend to support building this capacity in Eastern Canada, since the metal would be directed toward markets in the US Midwest and East. Under this scenario, Mexico would provide its surplus concentrates to US smelters.

A different scenario would have Mexico move to balance in mine and smelter capacity by adding 100,000 tonnes of smelter capacity. US smelters would then have to turn to other suppliers, including Canada, for more concentrates. An additional 50,000 tonnes of capacity through incremental expansions in Canada could then be accommodated to achieve slab self-sufficiency.

Europe: Since Europe is dependent on imported concentrates and since its 1994 capacity would be adequate to support domestic demand and exports to Eastern Europe through 2000, it would not be a logical region for additional smelter capacity.

In the absence of additional smelter capacity, however, Europe could not sustain its exports to the US, Africa and the Middle East. We have already noted that the US market could well be pre-empted by increased Canadian and Mexican sales to the US. The Africa/Middle Eastern regions slab import needs of about 100,000 tpy would most likely be met through South American exports.

Africa/Middle East: We would not expect this region to try to achieve self-sufficiency in slab zinc because of its sprawling geography. We would expect the region to continue to export concentrates and import metal.

South America: Based on the scenario presented above, South America could become the supplier of the small volume of inter-regional exports of slab zinc needed by 2000. An additional 150,000-200,000 tonnes of capacity by 2000 would be adequate to supply the import needs of Australasia (100,000 tonnes) and Africa/Middle East (100,000 tonnes). This would reduce South American concentrate exports to Europe to about 250,000-300,000 tonnes by 2000.

In summary, based on logistical considerations -- concentrate availability and slab zinc demand in 2000 and 1994 smelter capacity -- it would be reasonable to expect that the needed 750,000 tonnes of new smelter capacity would come from Australasia (400,000 tonnes), North America (150,000 tonnes) and South America (200,000 tonnes).

This scenario which indicates a major shift toward regional self-sufficiency in zinc is based primarily on logistical considerations. Of course, logistics is not the sole consideration in the structuring of any market.

The decision on whether or not to build zinc smelter capacity in a certain region is not based solely on regional concentrate availability and the regional market for slab zinc, although these are very important considerations. The cost of new smelter capacity and its revenue generating potential must also be considered and these can vary quite widely by region. To take an extreme example, a smelter could be economically built in a country with low labor costs, low electricity costs and a high-priced local sulfuric acid market, even if concentrates had to be imported and the resultant slab zinc exported. In other words, very low production costs, including the acid credit, could more than offset the negative logistics and make such a smelter an attractive investment.

We will examine smelter costs and revenues later in this report.

I.8 Alternative Economic Scenario

We have also simulated our zinc market model based on somewhat more bearish economic assumptions. We will not present all of the new variables, but the major economic indicators used in our "bear" scenario, and our base case scenario over the 1991 - 2000 period are as follows.

MAJOR ECONOMIC INDICATORS
1991-2000
(Annual Average % Growth)

	BASE CASE	BEAR SCENARIO
U.S. Industrial Production	2.13	1.59
Japanese Industrial Production	3.32	3.12
Canadian Industrial Production	2.42	1.86
European Industrial Production	2.76	2.42
Rest Of World Gross National Production	3.58	3.08

The impact of this slower rate of economic growth would be to reduce the annual average forecast rate of zinc consumption growth from 2.08 percent to 1.5 percent. This would produce a level of consumption in 2000 of 5,152,000 tonnes --328,000 tonnes less than in our base case forecast.

(Tables incorporating our base case and bear scenario zinc market forecasts are presented in Appendices D and E, respectively.)

The lower rate of demand growth means that less new mine capacity will have to be developed. In 2000 the bear scenario mine capacity level becomes 6,5950,000 tonnes -- 358,000 tonnes less than in the base case. The mine capacity utilization rates

--which are driven by price -- are somewhat lower in the bear scenario and mine production comes in at 2,257,000 tonnes. This is 362,000 tonnes less than in the base case.

We have not altered our assumptions of East/West net trade in zinc concentrates and slab, nor our assumptions as to the growth in secondary refined production from the base case. The reason we have not altered our secondary refined production forecast is that the increase in secondary production will stem primarily from the increased recycling of steel mill flue dust. This will be driven by environmental considerations rather than conditions in the zinc market.

Thus, our bear scenario forecast of total refined production in 2000 is 6,237,000 tonnes, or 341,000 tonnes less than in the base case.

The bear scenario produces larger surpluses in the 1992-1994 period and pushes stocks up to 704,000 tonnes in 1994 --143,000 tonnes higher than in the base case. As a result, prices remain depressed through 1994 -- at below 50 cents in constant 1990 US dollar terms.

These low prices act to depress mine operating rates and to deter the development of new mine capcity after 1994. As a result the bear scenario produces larger market deficits over the 1995-1997 period and by the end of 1997 stocks are only 16,000 tonnes higher than in the base case. Prices in constant dollar terms recover to 62 cents in 1997 -- just a shade lower than in the base case.

Small deficits from 1998-2000 allow prices to edge higher, reaching 64.4 cents in 2000 (in constant 1990 dollar terms). The price spike in 2000 under the base case does not occur in the bear scenario.

Thus, the self-correcting mechanisms of a free market come into play. The lower prices developed over the first half of the decade in the bear scenario force corrective measures and the price performance over the second half of the decade is not too much worse than in the base case. The five year constant 1990 dollar average for 1996-2000 in the bear scenario is 62.5 cents, compared with 66.4 cents.

There would be, however, a significant difference in the amount of new smelter capacity needed under the bear scenario. The following table presents the same calculation as was undertaken in the base case (000 tonnes).

WESTERN WORLD PRIMARY SMELTER BALANCE
BEAR SCENARIO
(000 tonnes)

	1994	1995	1996	1997	1998	1999	2000
Concentrate Production	**5679**	**5647**	**5734**	**5831**	**5958**	**6109**	**6256**
East Bloc Net Imports (-)	**---**	**---**	**40**	**60**	**80**	**120**	**150**
Direct-use Oxide (-)	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Western Concentrate Supply	**5675**	**5643**	**5690**	**5767**	**5874**	**5985**	**6102**
Recoverable Zinc	**5334**	**5304**	**5370**	**5456**	**5564**	**5695**	**5784**
1994 Effective Primary Capacity	**5604**	**5604**	**5604**	**5604**	**5604**	**5604**	**5604**
Smelter Capacity surplus (+)	**270**	**300**	**234**	**148**	**40**		
deficit (-)						**91**	**180**

In the base case, a smelter capacity deficit appears in 1997 at 79,000 tonnes and this increases to 524,000 in 2000. In the bear scenario, the deficit does not emerge until 1999 at 91,000 tonnes and it increases to only 180,000 in 2000.

However, as we noted earlier, it would be close to impossible for the industry to ever achieve production equal to effective primary capacity. Each smelter would have to match its historical maximum in the same year. Thus, there must be a safety margin to assure that all concentrates could be smelted in each year. We estimate that the safety margin would have to be about 225,000 tonnes. On that basis, the need for additional capacity would emerge in 1997 at 77,000 tonnes and would rise to about 405,000 in 2000. That would compare with 750,000 tonnes of needed new capacity by 2000 in the base case.

Turning to North America, the bear scenario reduces consumption sufficiently to negate the need for any additional smelter capacity. The calculation is as follows (000 tonnes):

NORTH AMERICA PRIMARY SMELTER BALANCE
BEAR SCENARIO
(000 tonnes)

	1995	1996	1997	1998	1999	2000
Consumption	1289	1269	1271	1274	1294	1311
Secondary Production (-)	118	122	127	131	135	140
Primary Consumption	1171	1146	1144	1142	1158	1171
Effective Primary Smelter Capacity (1994)	1235	1235	1235	1235	1235	1235
Surplus Smelter Capacity To Primary Demand	64	89	91	93	77	64

As this table shows, our bearish economic scenario reduces consumption growth from 1995 to 2000 to a mere 22,000 tonnes and that is matched by the growth in secondary production. The effective primary smelter of 1,235,000 tonnes in 1994 would be just about adequate to meet regional demand. Thus, any further increase in smelter capacity under the bear scenario would have to be aimed at export markets. Certainly Europe and, probably Australasia, would be self-sufficient in terms of slab production and consumption. Thus, a North American smelter aimed at the export market would be a dubious investment.

II. ZINC SMELTER PRODUCTION COSTS

II.1 Introduction

In this chapter we will first examine operating costs of zinc smelters operating in 1991. We will then examine operating costs in 1995 for existing smelters and eight planned or potential smelters. These eight plants include electrolytic smelters in France, New Brunswick, Indonesia, Queensland and Japan, and Imperial Smelting Furnace (ISF) smelters in New Brunswick, Thailand and Japan.

We will then examine the capital costs of these eight potential greenfield smelters, as well as their full production costs.

Next we will turn to the capital costs of potential incremental or brownfield expansions and compare the full production costs of greenfield versus brownfield expansions.

Lastly, we will examine the current environmental issues for zinc smelters and mines and discuss the implications for greenfield projects and incremental expansions in light of increasing stringency in regulations.

II.2 Operating Costs Of Zinc Smelters

In the analysis, net operating costs are calculated as gross operating costs less credits for by-products that are recovered by the smelter but for which no payment is made to the mine. These include cadmium, bismuth, germanium, gold and silver, as well as sulfuric acid, elemental sulfur and gypsum produced from the sulfur content of the concentrate. ISFs also receive a credit for the lead they recover above the amount paid for to the mine.

The range of net operating costs in 1991 is from $373/tonne of slab zinc at Trail in British Columbia to $2,116/tonne at the Sulfacid plant in Argentina. The Argentine and both Peruvian smelters are very high cost in 1991 because of government exchange rate policies aimed at curbing breakaway inflation. Excluding these three aberrations, the highest cost smelter is Crotone in Italy with a net operating cost of $1,142/tonne of zinc. The three Brazilian smelters are also suffering from governmental anti-inflation policies.

Costs of smelters around the fiftieth percentile in terms of cumulative production have costs of about $500.

In 1995, the net operating cost range, including the eight potential smelters, would be from $313 to $1,321/tonne zinc. Thus, the lower end of the cost schedule would actually be below the 1991 cost curve, despite inflation. This is because some of the potential smelters would have very low operating costs and because we expect a significant improvement in by-product metal prices. The Indonesian electrolytic smelter would have the lowest cost. The Crotone smelter would be at the top of the cost curve in 1995. It is, of course, possible that badly needed streamlining at Crotone will be undertaken by 1995, but we have no firm grounds for making that assumption.

The mean net operating cost, i.e. at the fiftieth percentile, in 1995 would be around $540. That would be only about 8 percent higher than in 1991.

If we examine gross operating costs -- prior to by-product credits -- for a smelter near the mean cost in 1991, e.g. Clarksville in the US, we find that labor costs account for about 23 percent, electricity about 45 percent and supplies about 29 percent. While this breakdown may be considered fairly typical, there is considerable variation. The Iijima smelter in Japan has net operating costs close to Clarksville in 1991, but its gross cost breakdown is about 70 percent electricity, 10 percent labor and 22 percent supplies. Moreover, Iijima has gross operating costs 32 percent higher than Clarksville, but its by-product credits are almost four times as great despite the fact that Clarksville has a better than average by-product credit from the germanium in its concentrate feed.

We will now examine the key components of net operating costs in 1991 and 1995.

The tables listing the rankings of smelters have highlighted the greenfield projects in 1995. The smelters under consideration for incremental expansions are also highlighted but the costs only reflect their current capacity.

II.2.1 Labor and Benefit Costs

In 1991 the range of labor costs per tonne of zinc production is from $33 at Kolwezi in Zaire to $441 at the Samim ISF in Italy. (The labor cost at Sulfacid is highly distorted at an astronomical $1,069.) In 1995 the range would be from $12 at the potential Indonesian smelter to $531 at the Samim ISF.

The rankings in the following tables show that the low-wage developing countries have a decided advantage in this cost input. Hourly wage rates in Thailand, Brazil, Mexico, Peru, South Africa and Zaire are all below $4/hour. In Zaire the hourly rate is $1.01.

Once we move to smelters in the industrialized world, the key determinants of labor costs per tonne of metal are the degree of automation at each smelter and the domestic currency value against the US dollar. If a country's currency is appreciating against the dollar, its labor costs in dollar terms will increase by more than the increase in local denominated wage rates.

All of the Japanese electrolytic smelters are in the lower two thirds of the 1991 cost schedule. Wage rates are high, but the smelters are highly automated and efficiently run.

The three US smelters are in the lower three quarters of the schedule. Clarksville is low cost at the twenty-ninth percentile. Bartlesville and Sauget are near the seventy-fifth percentile. Bartlesville is a very small smelter, while Sauget has relatively higher wage rates.

The Canadian smelters fall near the middle of the range. Their ranking will improve once the over-valued Canadian dollar begins to decline against the US dollar.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING LABOR & BENEFIT COSTS IN 1991

			PRODUCTION	CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	235.0	235.0	4.7
2	Chanderija	25.3	28.0	263.0	5.3
3	Kolwezi	33.4	27.0	290.0	5.9
4	Onsan	50.1	178.2	468.2	9.5
5	Paedang	50.9	71.0	539.2	10.9
6	Juiz Fora	86.4	57.6	596.8	12.1
7	Torreon	86.6	103.5	700.3	14.1
8	Potosi	86.9	90.4	790.7	16.0
9	Tres Marias	93.2	69.1	859.8	17.4
10	S Africa	97.0	90.0	949.8	19.2
11	Iijima	101.5	152.9	1102.7	22.3
12	Itaguai	117.0	41.6	1144.3	23.1
13	Budel	120.4	210.0	1354.3	27.4
14	Clarksville	123.0	95.5	1449.8	29.3
15	Annaka	127.4	105.6	1555.5	31.4
16	Kidd Creek	132.0	131.0	1686.5	34.1
17	Datteln	133.1	170.0	1856.5	37.5
18	A de Zinc	134.8	249.2	2105.7	42.5
19	Auby-Douai	144.8	178.4	2284.0	46.1
20	Akita	145.8	84.4	2368.4	47.9
21	Risdon	146.6	198.0	2566.4	51.9
22	Valleyfield	161.4	211.6	2778.0	56.1
23	Nordenham	167.0	126.0	2904.0	58.7
24	Flin Flon	168.6	73.1	2977.1	60.2
25	Trail	175.8	275.5	3252.6	65.7
26	Hikoshima	184.2	52.1	3304.6	66.8
27	Kamioka	194.7	54.0	3358.6	67.9
28	Norzink	197.9	128.8	3487.4	70.5
29	Avonmouth	215.4	99.0	3586.4	72.5
30	Bartlesville	216.2	50.0	3636.4	73.5
31	Sauget	231.1	75.8	3712.2	75.0
32	Samim Elec	233.6	78.4	3790.7	76.6
33	Balen	240.2	171.0	3961.7	80.0
34	Cajamarquilla	249.6	66.3	4028.0	81.4
35	Hachinohe	254.2	85.8	4113.8	83.1
36	Kokkola	275.0	168.3	4282.1	86.5
37	Duisburg	288.9	95.0	4377.1	88.4
38	Crotone	296.7	99.0	4476.1	90.4
39	Cockle Creek	313.3	72.0	4548.1	91.9
40	La Oroya	320.3	63.5	4611.6	93.2
41	Noyelles	340.7	86.1	4697.7	94.9
42	Harima	340.8	67.2	4764.9	96.3
43	Overpelt	415.9	90.0	4854.9	98.1
44	Samim ISF	440.8	63.0	4917.9	99.4
45	Sulfacid	1069.0	31.4	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING LABOR & BENEFIT COSTS IN 1995

			PRODUCTION	CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	260.0	260.0	4.1
2	Indo Elec	12.2	152.0	412.0	6.6
3	Chanderija	20.3	66.5	478.5	7.6
4	Kolwezi	41.6	21.6	500.1	8.0
5	Torreon	50.7	174.6	674.7	10.7
6	Itaguai	56.2	93.5	768.2	12.2
7	Paedang	63.4	71.0	839.2	13.3
8	Onsan	67.7	198.0	1037.2	16.5
9	Potosi	70.9	90.4	1127.6	17.9
10	Juiz Fora	71.6	60.0	1187.6	18.9
11	Tres Marias	79.3	69.1	1256.7	20.0
12	Cajamarquilla	81.9	76.5	1333.2	21.2
13	Thai ISF	105.4	57.0	1390.2	22.1
14	Australia Elec	107.3	152.0	1542.2	24.5
15	La Oroya	112.2	66.2	1608.5	25.6
16	Japan Elec	115.1	152.0	1760.5	28.0
17	S Africa	119.0	90.0	1850.5	29.4
18	A de Zinc	127.6	306.9	2157.4	34.3
19	Iijima	128.0	152.9	2310.2	36.7
20	France Elec	129.5	152.0	2462.2	39.2
21	NB Elec	140.2	152.0	2614.2	41.6
22	Kidd Creek	142.4	131.0	2745.2	43.7
23	Clarksville	144.4	95.5	2840.8	45.2
24	Budel	148.5	210.0	3050.8	48.5
25	Datteln	156.9	178.0	3228.8	51.4
26	Annaka	160.6	105.6	3334.4	53.0
27	Flin Flon	165.0	76.1	3410.6	54.2
28	Risdon	165.0	198.0	3608.6	57.4
29	Valleyfield	168.7	218.5	3827.1	60.9
30	Trail	178.5	287.1	4114.2	65.4
31	Akita	183.8	84.4	4198.5	66.8
32	Auby-Douai	187.5	178.4	4376.9	69.6
33	Tomakomai	191.9	114.0	4490.9	71.4
34	Avonmouth	200.2	99.0	4589.9	73.0
35	Nordenham	202.1	126.0	4715.9	75.0
36	Norzink	223.5	133.0	4848.9	77.1
37	Hikoshima	232.3	52.1	4901.0	78.0
38	Kamioka	233.5	58.3	4959.3	78.9
39	Bartlesville	253.8	50.0	5009.2	79.7
40	Sauget	271.2	75.8	5085.1	80.9
41	Samim Elec	281.2	78.4	5163.5	82.1
42	Balen	295.4	171.0	5334.5	84.8
43	NB ISF	298.9	95.0	5429.5	86.4
44	Hachinohe	320.5	85.8	5515.4	87.7
45	Kokkola	320.6	168.3	5683.7	90.4
46	Sulfacid	342.8	31.4	5715.0	90.9
47	Duisburg	349.6	95.0	5810.0	92.4
48	Cockle Creek	352.6	72.0	5882.0	93.6
49	Crotone	357.1	99.0	5981.0	95.1
50	Harima	429.7	67.2	6048.2	96.2
51	Noyelles	441.3	86.1	6134.3	97.6
52	Overpelt	511.6	90.0	6224.3	99.0
53	Samim ISF	530.5	63.0	6287.3	100.0

European smelters cover a wide range of labor costs. Budel is the lowest cost, sitting at the twenty-seventh percentile. Five of the eleven electrolytic smelters are in the upper quartile. Some are simply overmanned, while others suffer from strong local currencies and, hence, high dollar-equivalent wage rates.

The Risdon smelter in Australia sits near the middle of the cost curve despite an over-valued Australian dollar.

The ISF smelters operating in Europe, Japan and Australia in 1991 range upward from the seventieth percentile, with Avonmouth in the UK as the lowest cost and Samim as the highest. While ISF technology is somewhat more labor intensive than electrolytic technology, our costing methodology contributes to the seeming labor inefficiency of the ISFs. We have followed the industry practice in treating the ISFs as zinc smelters producing a lead by-product. Thus, the entire labor force is charged to the zinc production. Labor costs per tonne would look much better if they were apportioned to both the zinc and lead produced at the smelter.

The 1995 labor cost schedule is quite similar to 1991. Again, the smelters in low-wage developing countries have very low labor inputs per tonne of production. The potential Indonesian smelter has the lowest labor input.

Labor costs at the Canadian smelters would increase very modestly from 1991 due to an assumed weakening of the Canadian dollar. There is little shift in the rankings of the US and

European smelters. The Peruvian smelters greatly reduce their cost inputs with the assumed removal of governmental exchange regulations.

The five potential electrolytic smelters will all be near or below the mid point of the cost curve in labor costs, since new smelters would contain a high degree of automation. The Thai ISF would be low cost due to low wage rates. The Japanese ISF would be at the seventy-first percentile and the New Brunswick ISF would be at the eighty-sixth percentile. The New Brunswick ISF would probably be treating lower grade concentrate and, thus, would require more personnel for material handling.

II.2.2. Electricity Costs

The ISF process is not electricity intensive. The 1991 range per tonne of zinc produced is from $48 at Cockle Creek in Australia to $145 at Samim in Italy. Cockle Creek pays 42 mills for electricity, while Samim pays 127 mills.

Of the electrolytic smelters, Trail has the lowest electricity cost of $57/tonne, while Crotone has the highest at $640/tonne. The electricity input variation is primarily due to the cost paid per KWH, but plant efficiency is also an important factor.

Smelters based on hydro-electric power all have low electricity inputs. Trail has the lowest power costs of all the smelters -- 17 mills per KWH. The other three Canadian smelters also have low power costs in the low to mid 30 mill range.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING ELECTRICITY COSTS IN 1991

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	235.0	235.0	4.7
2	Cockle Creek	45.6	72.0	307.0	6.2
3	Trail	56.9	275.5	582.5	11.8
4	Duisburg	70.6	95.0	677.5	13.7
5	Noyelles	72.4	86.1	763.6	15.4
6	Avonmouth	77.5	99.0	862.6	17.4
7	Chanderija	81.4	28.0	890.6	18.0
8	Hachinohe	101.9	85.8	976.4	19.7
9	Risdon	103.0	198.0	1174.4	23.7
10	Harima	103.6	67.2	1241.6	25.1
11	Norzink	111.3	128.8	1370.4	27.7
12	Kokkola	116.8	168.3	1538.7	31.1
13	Valleyfield	132.0	211.6	1750.3	35.4
14	Samim ISF	137.4	63.0	1813.3	36.6
15	Flin Flon	139.7	73.1	1886.4	38.1
16	Torreon	140.0	103.5	1989.9	40.2
17	Potosi	143.0	90.4	2080.3	42.0
18	A de Zinc	143.4	249.2	2329.5	47.1
19	Kidd Creek	157.5	131.0	2460.5	49.7
20	S Africa	160.1	90.0	2550.5	51.5
21	Kolwezi	193.3	27.0	2577.5	52.1
22	Paedang	198.5	71.0	2648.5	53.5
23	Auby-Douai	202.1	178.4	2826.8	57.1
24	Overpelt	210.1	90.0	2916.8	58.9
25	Sauget	210.3	75.8	2992.7	60.5
26	Itaguai	214.5	41.6	3034.2	61.3
27	Cajamarquilla	215.3	66.3	3100.5	62.6
28	Juiz Fora	216.6	57.6	3158.1	63.8
29	Budel	225.9	210.0	3368.1	68.1
30	Clarksville	238.3	95.5	3463.7	70.0
31	Balen	239.8	171.0	3634.7	73.4
32	La Oroya	241.3	63.5	3698.2	74.7
33	Bartlesville	244.1	50.0	3748.1	75.7
34	Tres Marias	248.9	69.1	3817.2	77.1
35	Nordenham	264.7	126.0	3943.2	79.7
36	Datteln	278.2	170.0	4113.2	83.1
37	Onsan	294.5	178.2	4291.4	86.7
38	Hikoshima	433.5	52.1	4343.5	87.8
39	Iijima	435.9	152.9	4496.4	90.9
40	Kamioka	437.8	54.0	4550.4	91.9
41	Akita	456.0	84.4	4634.8	93.6
42	Annaka	458.6	105.6	4740.4	95.8
43	Sulfacid	477.9	31.4	4771.8	96.4
44	Samim Elec	493.6	78.4	4850.2	98.0
45	Crotone	640.3	99.0	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING ELECTRICITY COSTS IN 1995

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	260.0	260.0	4.1
► 2	NB ISF	36.5	95.0	355.0	5.6
3	Chanderija	45.4	66.5	421.5	6.7
4	Cockle Creek	53.1	72.0	493.5	7.8
► 5	Trail	56.3	287.1	780.6	12.4
6	Duisburg	77.9	95.0	875.6	13.9
7	Noyelles	79.9	86.1	961.7	15.3
► 8	Thai ISF	97.0	57.0	1018.7	16.2
9	Avonmouth	97.2	99.0	1117.7	17.8
► 10	Tomakomai	104.2	114.0	1231.7	19.6
► 11	Risdon	108.5	198.0	1429.7	22.7
12	Hachinohe	119.2	85.8	1515.5	24.1
13	Norzink	120.7	133.0	1648.5	26.2
14	Harima	121.2	67.2	1715.7	27.3
15	Flin Flon	128.8	76.1	1791.8	28.5
16	Kokkola	128.9	168.3	1960.1	31.2
► 17	Valleyfield	130.4	218.5	2178.6	34.7
► 18	France Elec	135.0	152.0	2330.6	37.1
► 19	NB Elec	144.2	152.0	2482.6	39.5
► 20	A de Zinc	150.9	306.9	2789.5	44.4
21	Samim ISF	151.6	63.0	2852.5	45.4
► 22	Australia Elec	153.2	152.0	3004.5	47.8
23	Kidd Creek	155.4	131.0	3135.5	49.9
► 24	Torreon	156.1	174.6	3310.1	52.6
25	Potosi	161.0	90.4	3400.5	54.1
► 26	Indo Elec	176.6	152.0	3552.5	56.5
► 27	Cajamarquilla	178.6	76.5	3629.0	57.7
28	Itaguai	197.0	93.5	3722.5	59.2
29	S Africa	199.8	90.0	3812.5	60.6
30	La Oroya	200.2	66.2	3878.8	61.7
► 31	Juiz Fora	206.7	60.0	3938.8	62.6
32	Paedang	223.4	71.0	4009.8	63.8
33	Kolwezi	226.4	21.6	4031.4	64.1
34	Tres Marias	237.6	69.1	4100.5	65.2
35	Sauget	246.0	75.8	4176.3	66.4
36	Overpelt	252.0	90.0	4266.3	67.9
37	Auby-Douai	255.0	178.4	4444.7	70.7
38	Clarksville	263.1	95.5	4540.2	72.2
39	Bartlesville	285.6	50.0	4590.2	73.0
40	Budel	287.0	210.0	4800.2	76.3
41	Balen	287.5	171.0	4971.2	79.1
42	Nordenham	292.2	126.0	5097.2	81.1
43	Sulfacid	323.0	31.4	5128.5	81.6
44	Datteln	326.3	178.0	5306.5	84.4
► 45	Onsan	333.3	198.0	5504.5	87.6
► 46	Japan Elec	482.3	152.0	5656.5	90.0
47	Hikoshima	507.2	52.1	5708.6	90.8
► 48	Iijima	509.9	152.9	5861.5	93.2
49	Kamioka	512.1	58.3	5919.8	94.2
50	Akita	533.5	84.4	6004.2	95.5
51	Annaka	536.5	105.6	6109.8	97.2
52	Samim Elec	544.8	78.4	6188.3	98.4
53	Crotone	706.7	99.0	6287.3	100.0

Electricity costs in Europe range widely. Kokkola in Finland and Odda in Norway are hydro-based and pay 30 mills. Asturiana in Spain receives a preferential rate of 33 mills. Power costs in Belgium, France and the Netherlands are in the 50 mill range, German rates are in the 65-76 mill range, while the Italian smelters pay 128 mills.

Japanese electricity rates are also very high at 116 mills, while the Korean smelter pays 78 mills. Brazilian power costs in 1991 are 49 mills, while US smelters pay 51-58 mills.

The electricity input cost per tonne of metal is low in Canada at $57-158, in Australia at $103, in Mexico at $140-143, in Spain at $143, in Norway at $111 and in Finland at $117. Other European smelters, except for those in Italy, are in the range of $202-278. Italian costs are the highest in the world at $493-640. Japanese costs are the next highest at $434-459. US costs are in the range of $210-244.

The electricity cost schedule in 1995 shows the same pattern as 1991. Trail remains the lowest cost of the electrolytic smelters. Because of the assumed weakening of the Canadian dollar, its US dollar denominated electricity costs in 1995 are about the same as in 1991 -- $56/tonne of zinc. The other Canadian smelters fall within a range of $130-155. The New Brunswick smelter would come in at $144.

As in 1991, the two Italian electrolytic smelters have the highest electricity input costs at $545-707. The Japanese are the second highest at $482-537. The greenfield Japanese smelter would have the lowest cost of the six Japanese electrolytic plants, reflecting the most up-to-date equipment.

Of the five potential new electrolytic smelters, the French smelter would have the lowest electricity input at $135. New Brunswick would be second at $144, followed by Queensland at $153, Indonesia at $176 and Japan at $482. All but the Japanese smelter fall in the lower half of the electricity cost curve.

II.2.3 Thermal Energy Costs

This is not an important input for the electrolytic smelters. Among the ISFs, however, it can be important for those smelters burdened by protected high cost domestic coal supplies. In the 1995 schedule, three smelters are so burdened. Noyelles in France has a cost of $133, Avonmouth in the UK is at $158 and Duisburg in Germany tops the list at $251.

The other ISFs have 1995 thermal energy inputs ranging from $37 in New Brunswick to $57 in Thailand.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING THERMAL ENERGY COSTS IN 1991

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	235.0	235.0	4.7
2	Bartlesville	0.2	50.0	285.0	5.8
3	Risdon	1.3	198.0	483.0	9.8
4	Nordenham	1.3	126.0	609.0	12.3
5	Budel	1.5	210.0	819.0	16.5
6	Clarksville	1.5	95.5	914.5	18.5
7	Auby-Douai	1.6	178.4	1092.9	22.1
8	Overpelt	1.7	90.0	1182.9	23.9
9	Samim Elec	1.8	78.4	1261.3	25.5
10	Onsan	1.9	178.2	1439.5	29.1
11	Balen	2.2	171.0	1610.5	32.5
12	Paedang	2.4	71.0	1681.5	34.0
13	Torreon	2.5	103.5	1785.0	36.1
14	Trail	2.6	275.5	2060.5	41.6
15	Itaguai	2.7	41.6	2102.1	42.5
16	Cajamarquilla	3.3	66.3	2168.4	43.8
17	Tres Marias	3.4	69.1	2237.5	45.2
18	Juiz Fora	3.4	57.6	2295.1	46.4
19	Norzink	3.7	128.8	2423.9	49.0
20	Potosi	3.8	90.4	2514.3	50.8
21	Datteln	3.8	170.0	2684.3	54.2
22	Kokkola	3.9	168.3	2852.6	57.6
23	A de Zinc	4.8	249.2	3101.8	62.7
24	Flin Flon	4.9	73.1	3174.8	64.1
25	Valleyfield	6.9	211.6	3386.4	68.4
26	Kidd Creek	7.0	131.0	3517.4	71.1
27	Sauget	7.3	75.8	3593.3	72.6
28	Crotone	10.4	99.0	3692.3	74.6
29	Cockle Creek	10.8	72.0	3764.3	76.1
30	Iijima	11.1	152.9	3917.2	79.1
31	Annaka	12.0	105.6	4022.8	81.3
32	Akita	12.6	84.4	4107.2	83.0
33	Kamioka	13.8	54.0	4161.2	84.1
34	Hikoshima	13.9	52.1	4213.3	85.1
35	Kolwezi	14.9	27.0	4240.3	85.7
36	S Africa	15.7	90.0	4330.3	87.5
37	La Oroya	16.8	63.5	4393.8	88.8
38	Sulfacid	19.5	31.4	4425.1	89.4
39	Samim ISF	29.2	63.0	4488.1	90.7
40	Chanderija	29.9	28.0	4516.1	91.2
41	Harima	32.4	67.2	4583.3	92.6
42	Hachinohe	37.0	85.8	4669.1	94.3
43	Noyelles	107.2	86.1	4755.2	96.1
44	Avonmouth	124.3	99.0	4854.2	98.1
45	Duisburg	184.6	95.0	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING THERMAL ENERGY COSTS IN 1995

			PRODUCTION		CUMULATIVE	
			$/TONNE	(000T)	TOTAL	PERCENT
	1	Not Costed	0	260.0	260.0	4.1
	2	Bartlesville	0.2	50.0	310.0	4.9
►	3	Risdon	1.7	198.0	508.0	8.1
	4	Budel	1.7	210.0	718.0	11.4
	5	Nordenham	1.9	126.0	844.0	13.4
	6	Clarksville	2.1	95.5	939.5	14.9
	7	Auby-Douai	2.3	178.4	1117.9	17.8
►	8	Onsan	2.3	198.0	1315.9	20.9
	9	Overpelt	2.4	90.0	1405.9	22.4
	10	Samim Elec	2.4	78.4	1484.3	23.6
►	11	Trail	2.6	287.1	1771.4	28.2
	12	Itaguai	3.0	93.5	1864.9	29.7
	13	Balen	3.1	171.0	2035.9	32.4
►	14	Torreon	3.2	174.6	2210.5	35.2
	15	Paedang	3.2	71.0	2281.5	36.3
►	16	Cajamarquilla	4.3	76.5	2358.0	37.5
►	17	Australia Elec	4.3	152.0	2510.0	39.9
	18	Tres Marias	4.5	69.1	2579.1	41.0
►	19	Juiz Fora	4.5	60.0	2639.1	42.0
	20	Norzink	4.9	133.0	2772.1	44.1
	21	Datteln	5.3	178.0	2950.1	46.9
	22	Kokkola	5.3	168.3	3118.4	49.6
	23	Potosi	5.4	90.4	3208.8	51.0
►	24	A de Zinc	6.7	306.9	3515.7	55.9
	25	Flin Flon	6.9	76.1	3591.8	57.1
	26	Sauget	8.5	75.8	3667.7	58.3
►	27	Valleyfield	9.6	218.5	3886.2	61.8
	28	Kidd Creek	9.8	131.0	4017.2	63.9
►	29	NB Elec	11.9	152.0	4169.2	66.3
►	30	France Elec	12.0	152.0	4321.2	68.7
►	31	Indo Elec	12.8	152.0	4473.2	71.1
	32	Cockle Creek	13.4	72.0	4545.2	72.3
	33	Crotone	13.7	99.0	4644.2	73.9
►	34	Japan Elec	15.5	152.0	4796.2	76.3
►	35	Iijima	15.9	152.9	4949.1	78.7
	36	Annaka	17.2	105.6	5054.7	80.4
	37	Akita	18.0	84.4	5139.1	81.7
	38	Kolwezi	19.2	21.6	5160.7	82.1
	39	Kamioka	19.4	58.3	5219.0	83.0
	40	Hikoshima	19.9	52.1	5271.1	83.8
	41	S Africa	20.7	90.0	5361.1	85.3
	42	La Oroya	22.1	66.2	5427.3	86.3
	43	Sulfacid	25.8	31.4	5458.7	86.8
►	44	NB ISF	36.6	95.0	5553.7	88.3
	45	Chanderija	37.6	66.5	5620.2	89.4
	46	Samim ISF	38.7	63.0	5683.2	90.4
	47	Harima	42.3	67.2	5750.3	91.5
	48	Hachinohe	52.2	85.8	5836.2	92.8
►	49	Tomakomai	52.2	114.0	5950.2	94.6
►	50	Thai ISF	57.2	57.0	6007.2	95.5
	51	Noyelles	132.9	86.1	6093.3	96.9
	52	Avonmouth	158.4	99.0	6192.3	98.5
	53	Duisburg	250.9	95.0	6287.3	100.0

II.2.4 Coke Costs

The coke cost inputs per tonne of zinc produced at the ISFs are about equivalent of the electricity cost inputs for electrolytic smelters in the lower half of the cost curve. The Cockle Creek ISF in Australia has a low cost local supply and has far-and-away the lowest input per tonne of production in 1991 at $48. Coke costs at the other ISFs range from $115 at Noyelles to $156 at the Chanderija smelter in India.

By 1995 coke costs will increase by about 20-25 percent at most ISFs. Cockle Creek's costs increase the least -- 17 percent to $56. The other range upward from $141 in New Brunswick to $209 in India and Thailand.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING COKE COSTS IN 1991

	$/TONNE	PRODUCTION (OOOT)
Cockle Creek	48.3	72.0
Noyelles	115.1	86.1
Duisburg	121.1	95.0
Harima	124.2	67.2
Hachinohe	124.2	85.8
Avonmouth	133.6	99.0
Samim ISF	145.4	63.0
Chanderija	155.5	28.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING COKE COSTS IN 1995

	$/TONNE	PRODUCTION (OOOT)
Cockle Creek	56.3	72.0
► NB ISF	141.0	95.0
Noyelles	142.2	86.1
Duisburg	149.7	95.0
► Tomakomai	153.4	114.0
Harima	153.4	67.2
Hachinohe	153.4	85.8
Avonmouth	163.9	99.0
Samim ISF	179.6	63.0
Chanderija	209.2	66.5
► Thai ISF	209.2	57.0

II.2.5 Supplies and Equipment Costs

Four elements determine the range of a smelter's supply and equipment costs: technology, efficiency, proximity to suppliers and currency exchange rates.

The ISF process consumes less supplies than the electrolytic process. Electrolytic smelters that treat silicate ores must buy in sulfur and, thus, have the highest supply costs.

Five of the eight ISFs operating in 1991 have low costs in the range of $84 at Avonmouth to $133 at Harima. The Samim ISF is inefficient and its costs are $158. The new Chanderija ISF in India must import supplies and equipment making it the highest cost ISF at $299. The plant is operating at half of its full rated capacity this year and, thus, suffers from economies of scale. Unit costs should decline next year when the plant reaches design capacity.

The three smelters treating silicate concentrates are Paedang in Thailand and Itaguai and Tres Marias in Brazil. Their costs are in the range of $277-388.

Three other smelters have very high inputs in 1991, but this reflects government exchange control regulations that aim to discourage imports as part of an anti-inflation program. These countries are Argentina and Peru. The government regulations have had disastrous consequences for domestic zinc smelters that have to import supplies and equipment. The cost inputs for these three smelters range from $500 to $655. The other smelter with a very high supply cost is Kolwezi in Zaire, due to the high cost of shipping to the remote site.

The range of supplies and equipment costs at the other electrolytic smelters is from $94 at Trail to $232 at Flin Flon. As mentioned earlier, Flin Flon is now undergoing a modernization program.

The pattern does not change greatly in 1995, although the Peruvian and Argentine smelters see their costs come down considerably with the assumed removal of exchange rate controls.

Three ISFs -- New Brunswick, Tomakomai in Japan and Avonmouth have costs below $100. The lowest cost electrolytic smelters are Trail, Asturiana, Duisburg and Valleyfield -- in the range of $103-120.

The five potential electrolytic smelters fall in the middle third of the cost curve. The range of costs is $137 in Queensland to $169 in Japan.

The highest cost smelter in terms of supplies and equipment in 1995 would be Kolwezi, due to its high import need and remote location.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING SUPPLY & EQUIPMENT COSTS IN 1991

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	235.0	235.0	4.7
2	Avonmouth	84.4	99.0	334.0	6.7
3	Trail	93.7	275.5	609.5	12.3
4	Duisburg	95.4	95.0	704.5	14.2
5	Hachinohe	103.9	85.8	790.3	16.0
6	Noyelles	104.6	86.1	876.4	17.7
7	Valleyfield	108.4	211.6	1088.0	22.0
8	Budel	111.7	210.0	1298.0	26.2
9	Cockle Creek	112.0	72.0	1370.0	27.7
10	A de Zinc	112.3	249.2	1619.2	32.7
11	Onsan	118.2	178.2	1797.4	36.3
12	Risdon	119.7	198.0	1995.4	40.3
13	Datteln	125.1	170.0	2165.4	43.8
14	Balen	130.0	171.0	2336.4	47.2
15	Auby-Douai	130.6	178.4	2514.8	50.8
16	Harima	132.8	67.2	2581.9	52.2
17	Iijima	138.9	152.9	2734.8	55.3
18	Clarksville	152.5	95.5	2830.4	57.2
19	Samim ISF	157.8	63.0	2893.4	58.5
20	Kokkola	158.3	168.3	3061.7	61.9
21	Kidd Creek	159.8	131.0	3192.7	64.5
22	Norzink	161.3	128.8	3321.5	67.1
23	Nordenham	163.8	126.0	3447.5	69.7
24	Sauget	166.1	75.8	3523.3	71.2
25	Annaka	181.8	105.6	3629.0	73.3
26	S Africa	188.6	90.0	3719.0	75.1
27	Akita	201.9	84.4	3803.4	76.8
28	Bartlesville	202.0	50.0	3853.3	77.9
29	Overpelt	205.4	90.0	3943.3	79.7
30	Torreon	205.7	103.5	4046.8	81.8
31	Potosi	218.5	90.4	4137.2	83.6
32	Crotone	220.6	99.0	4236.2	85.6
33	Samim Elec	222.5	78.4	4314.6	87.2
34	Flin Flon	225.7	73.1	4387.7	88.7
35	Kamioka	231.2	54.0	4441.7	89.7
36	Hikoshima	231.6	52.1	4493.8	90.8
37	Paedang	276.7	71.0	4564.8	92.2
38	Chanderija	299.4	28.0	4592.8	92.8
39	Juiz Fora	333.7	57.6	4650.4	94.0
40	Tres Marias	368.2	69.1	4719.5	95.4
41	Itaguai	388.5	41.6	4761.1	96.2
42	Kolwezi	453.5	27.0	4788.1	96.7
43	Cajamarquilla	500.6	66.3	4854.4	98.1
44	Sulfacid	530.3	31.4	4885.7	98.7
45	La Oroya	655.0	63.5	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING SUPPLY & EQUIPMENT COSTS IN 1995

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	260.0	260.0	4.1
► 2	Tomakomai	89.3	114.0	374.0	5.9
► 3	NB ISF	94.9	95.0	469.0	7.5
4	Avonmouth	98.9	99.0	568.0	9.0
► 5	Trail	103.2	287.1	855.1	13.6
► 6	A de Zinc	105.0	306.9	1162.0	18.5
7	Duisburg	114.6	95.0	1257.0	20.0
► 8	Valleyfield	120.1	218.5	1475.5	23.5
9	Hachinohe	124.5	85.8	1561.3	24.8
10	Cockle Creek	128.7	72.0	1633.3	26.0
► 11	Onsan	130.4	198.0	1831.3	29.1
12	Noyelles	131.2	86.1	1917.4	30.5
13	Budel	135.2	210.0	2127.4	33.8
► 14	Australia Elec	136.8	152.0	2279.4	36.3
► 15	Risdon	137.6	198.0	2477.4	39.4
► 16	NB Elec	139.6	152.0	2629.4	41.8
► 17	Indo Elec	144.8	152.0	2781.4	44.2
18	Datteln	145.7	178.0	2959.4	47.1
► 19	Torreon	147.9	174.6	3134.0	49.8
20	Chanderija	150.6	66.5	3200.5	50.9
► 21	France Elec	151.2	152.0	3352.5	53.3
22	Balen	157.3	171.0	3523.5	56.0
23	Harima	159.2	67.2	3590.7	57.1
24	Auby-Douai	163.8	178.4	3769.0	59.9
► 25	Iijima	166.5	152.9	3921.9	62.4
► 26	Japan Elec	169.4	152.0	4073.9	64.8
27	Clarksville	176.6	95.5	4169.5	66.3
28	Kidd Creek	181.0	131.0	4300.5	68.4
► 29	Thai ISF	183.7	57.0	4357.5	69.3
30	Norzink	185.2	133.0	4490.5	71.4
31	Kokkola	187.0	168.3	4658.8	74.1
32	Samim ISF	189.0	63.0	4721.8	75.1
33	Sauget	192.2	75.8	4797.6	76.3
34	Nordenham	196.7	126.0	4923.6	78.3
35	Annaka	217.9	105.6	5029.3	80.0
36	S Africa	225.2	90.0	5119.3	81.4
37	Potosi	230.6	90.4	5209.7	82.9
38	Bartlesville	233.8	50.0	5259.6	83.7
39	Flin Flon	234.6	76.1	5335.7	84.9
40	Itaguai	237.3	93.5	5429.2	86.4
41	Akita	242.0	84.4	5513.6	87.7
42	Overpelt	248.6	90.0	5603.6	89.1
43	Crotone	264.1	99.0	5702.6	90.7
► 44	Cajamarquilla	266.3	76.5	5779.1	91.9
45	Samim Elec	266.4	78.4	5857.6	93.2
46	Kamioka	270.7	58.3	5915.9	94.1
47	Hikoshima	277.5	52.1	5968.0	94.9
48	Tres Marias	306.1	69.1	6037.1	96.0
► 49	Juiz Fora	309.3	60.0	6097.1	97.0
50	Sulfacid	328.3	31.4	6128.4	97.5
51	Paedang	328.7	71.0	6199.4	98.6
52	La Oroya	359.9	66.2	6265.7	99.7
53	Kolwezi	571.9	21.6	6287.3	100.0

II.2.6 Sulfur/Sulfuric Acid Credit

The main determinants of the sulfur credit which zinc smelters earn are the capture percentage of sulfur in concentrates, proximity to market and prices prevailing in regional markets.

Sulfur capture tends to be highest in countries with the most stringent environmental controls. As a group, the Japanese smelters have the highest capture at 96-98 percent. The most dilute gases are not suitable for conversion into acid, so the Japanese produce a gypsum by-product along with sulfuric acid.

In Europe, Crotone captures only 80 percent, but all others are in the 90-96 percent range. Very few smelters capture less than 90 percent of the sulfur in their concentrates. These exceptions are La Oroya in Peru (85 percent) and Zinc Corp. in South Africa (86 percent). The Flin Flon smelter does not have an acid plant and, thus, receives no sulfuric acid credit. The government has mandated that the plant must meet minimum sulfur emmission standards by January 1994.

A modernization program is underway to install a Sherritt Gordon pressure leach system which will convert the sulfur content of the concentrate into elemental sulfur, a relatively inert material that can be disposed of in a lined tailings pond. An alternative would be to upgrade the elemental sulfur into a marketable product. The determinant would be whether the net back price would exceed the cost of upgrading. Flin Flon is a considerable distance from major sulfur consumers.

The Japanese receive the largest sulfur credit because of close proximity to a protected and premium-priced home market. The Japanese are currently receiving an acid net back price (net of delivery cost) of about $72/tonne. This translates to a credit per tonne of zinc produced of $123-153. This just about balances out the labor cost input at the Japanese electrolytic smelters.

In Europe, smelters in close proximity to acid consumers get a net back price in the range of $46-48, as in Belgium, the Netherlands and Germany. Smelters that must ship their acid by vessel to other countries get net back prices of about $27-32, as in Norway and Finland.

In Canada, Valleyfield has some local niche markets and gets the best average net back price of $34. The net revenue on acid shipped to the Florida fertilizer plants is much less. The situation at Flin Flon will probably not improve when the switch over to elemental sulfur production is completed since the product is not suitable for consumers and the shipping distance to market is prohibitively high.

In the US, net back prices range from $29 to $43. The Mexican smelters receive net back prices in the $30-40 range. In Africa, Zinc Corp. has a South African market outlet and nets $47. The smelters in Thailand and Brazil treating silicate ores produce no acid and, moreover, have to buy acid or elemental sulfur for leaching.

The sulfur credits in 1991 per tonne of zinc produced are as follows:

Japan	$123-153	Peru	$19-38
Europe	$43-105	Mexico	$52-70
Canada	$0-66	Australia	$43-47
US	$48-64		

In 1995, we assume some inflation in acid prices and the range of credits per tonne of zinc would be:

Japan	$144-179	Peru	$21-42
Europe	$48-115	Mexico	$59-78
Canada	$0-77	Australia	$47-52
US	$53-70		

Of the eight potential smelters we have costed in 1995 , the Japanese electrolytic and ISF would get $144 and $150, respectively. The Indonesian smelter is assumed to be tied in with a fertilizer plant and would get an $80 credit. The Thai ISF could sell acid to the Paedang smelter which treats silicate concentrates and would get a $60 credit. The French smelter would get a $61 credit. New Brunswick's electrolytic and ISF smelters which would have to ship acid some distance to market and would get credits of only $37 and $52, respectively. The Queensland smelter would incur very high shipping costs to get acid to market and would get a credit of only $11.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING SULFURIC ACID CREDIT IN 1991

			PRODUCTION	CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Hachinohe	(153.2)	85.8	85.8	1.7
2	Harima	(153.2)	67.2	153.0	3.1
3	Annaka	(125.3)	105.6	258.6	5.2
4	Akita	(125.3)	84.4	343.0	6.9
5	Iijima	(124.0)	152.9	495.9	10.0
6	Hikoshima	(122.7)	52.1	548.0	11.1
7	Kamioka	(122.7)	54.0	602.0	12.2
8	Duisburg	(104.6)	95.0	697.0	14.1
9	Juiz Fora	(96.6)	57.6	754.6	15.2
10	Overpelt	(90.5)	90.0	844.6	17.1
11	Datteln	(78.7)	170.0	1014.6	20.5
12	Budel	(78.1)	210.0	1224.6	24.7
13	Balen	(78.0)	171.0	1395.6	28.2
14	S Africa	(78.0)	90.0	1485.6	30.0
15	Avonmouth	(74.0)	99.0	1584.6	32.0
16	Potosi	(69.5)	90.4	1675.0	33.8
17	Chanderija	(67.8)	28.0	1703.0	34.4
18	Noyelles	(66.8)	86.1	1789.1	36.1
19	Valleyfield	(65.6)	211.6	2000.7	40.4
20	Sauget	(63.5)	75.8	2076.5	42.0
21	Nordenham	(61.9)	126.0	2202.5	44.5
22	Kokkola	(58.4)	168.3	2370.8	47.9
23	A de Zinc	(56.9)	249.2	2620.0	52.9
24	Samim Elec	(55.7)	78.4	2698.5	54.5
25	Samim ISF	(55.3)	63.0	2761.5	55.8
26	Auby-Douai	(53.5)	178.4	2939.8	59.4
27	Clarksville	(52.0)	95.5	3035.4	61.3
28	Torreon	(51.7)	103.5	3138.9	63.4
29	Kidd Creek	(48.5)	131.0	3269.9	66.1
30	Bartlesville	(48.3)	50.0	3319.8	67.1
31	Norzink	(48.2)	128.8	3448.6	69.7
32	Cockle Creek	(47.2)	72.0	3520.6	71.1
33	Crotone	(43.4)	99.0	3619.6	73.1
34	Risdon	(43.2)	198.0	3817.6	77.1
35	Onsan	(39.1)	178.2	3995.8	80.7
36	Cajamarquilla	(37.8)	66.3	4062.1	82.1
37	Trail	(35.6)	275.5	4337.6	87.6
38	Sulfacid	(34.6)	31.4	4369.0	88.3
39	La Oroya	(18.7)	63.5	4432.5	89.6
40	Kolwezi	(7.8)	27.0	4459.5	90.1
41	Paedang	0	71.0	4530.5	91.5
42	Itaguai	0	41.6	4572.0	92.4
43	Flin Flon	0	73.1	4645.1	93.9
44	Tres Marias	0	69.1	4714.2	95.3
45	Not Costed	0	235.0	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING SULFURIC ACID CREDIT IN 1995

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
	1 Hachinohe	(179.3)	85.8	85.8	1.4
	2 Harima	(179.3)	67.2	153.0	2.4
►	3 Tomakomai	(149.6)	114.0	267.0	4.2
	4 Akita	(146.6)	84.4	351.4	5.6
	5 Annaka	(146.6)	105.6	457.0	7.3
►	6 Iijima	(145.1)	152.9	609.9	9.7
	7 Hikoshima	(143.6)	52.1	662.0	10.5
	8 Kamioka	(143.6)	58.3	720.3	11.5
►	9 Japan Elec	(143.6)	152.0	872.3	13.9
	10 Duisburg	(115.4)	95.0	967.3	15.4
►	11 Juiz Fora	(106.6)	60.0	1027.3	16.3
	12 Overpelt	(99.9)	90.0	1117.3	17.8
	13 Datteln	(86.9)	178.0	1295.3	20.6
	14 Budel	(86.2)	210.0	1505.3	23.9
	15 Balen	(86.1)	171.0	1676.3	26.7
	16 S Africa	(86.1)	90.0	1766.3	28.1
	17 Avonmouth	(81.7)	99.0	1865.3	29.7
►	18 Indo Elec	(80.0)	152.0	2017.3	32.1
	19 Potosi	(78.2)	90.4	2107.7	33.5
►	20 Valleyfield	(76.8)	218.5	2326.2	37.0
	21 Chanderija	(74.9)	66.5	2392.7	38.1
	22 Noyelles	(73.7)	86.1	2478.8	39.4
	23 Sauget	(70.1)	75.8	2554.7	40.6
	24 Nordenham	(68.3)	126.0	2680.7	42.6
	25 Kokkola	(64.4)	168.3	2849.0	45.3
►	26 A de Zinc	(62.8)	306.9	3155.9	50.2
	27 Samim Elec	(61.5)	78.4	3234.3	51.4
	28 Samim ISF	(61.0)	63.0	3297.3	52.4
►	29 France Elec	(61.0)	152.0	3449.3	54.9
►	30 Thai ISF	(60.4)	57.0	3506.3	55.8
►	31 Torreon	(59.3)	174.6	3680.9	58.5
	32 Auby-Douai	(59.0)	178.4	3859.2	61.4
	33 Clarksville	(57.4)	95.5	3954.8	62.9
	34 Kidd Creek	(53.5)	131.0	4085.8	65.0
	35 Bartlesville	(53.3)	50.0	4135.7	65.8
	36 Norzink	(53.2)	133.0	4268.7	67.9
	37 Cockle Creek	(52.1)	72.0	4340.7	69.0
►	38 NB ISF	(51.7)	95.0	4435.7	70.6
	39 Crotone	(47.9)	99.0	4534.7	72.1
►	40 Risdon	(47.7)	198.0	4732.7	75.3
►	41 Onsan	(43.1)	198.0	4930.7	78.4
►	42 Cajamarquilla	(41.8)	76.5	5007.2	79.6
►	43 Trail	(39.3)	287.1	5294.3	84.2
	44 Sulfacid	(38.2)	31.4	5325.7	84.7
►	45 NB Elec	(36.6)	152.0	5477.7	87.1
	46 La Oroya	(20.6)	66.2	5543.9	88.2
►	47 Australia Elec	(10.9)	152.0	5695.9	90.6
	48 Kolwezi	(8.6)	21.6	5717.5	90.9
	49 Not Costed	0	260.0	5977.5	95.1
	50 Tres Marias	0	69.1	6046.7	96.2
	51 Paedang	0	71.0	6117.7	97.3
	52 Flin Flon	0	76.1	6193.8	98.5
	53 Itaguai	0	93.5	6287.3	100.0

II.2.7 By-Product Metal Credits

The ISF smelters pay for lead in their concentrates, but they recover more than they pay the miner. The difference is applied as a credit against zinc production costs. Thus, all of the ISFs have valuable metal by-product credits.

Other metals that are recovered from zinc concentrate, but for which no payment is made to the mines, include cadmium, germanium, copper, gold and silver. Not all smelters are equipped to capture these by-product metals. Thus, concentrates with high by-product values tend to go to the smelters that can recover them.

Of the electrolytic smelters, the Japanese get the largest by-product credit in 1991 at $76. Overpelt gets the most of any European smelter at $31. Clarksville gets the largest credit of the American smelters at $18. Overpelt, Clarksville, Noyelles and Asturiana all recover germanium. Trail is the only Canadian smelter with a significant by-product credit -- $8. The Trail smelter recovers some germanium from Red Dog concentrates.

Many smelters recover cadmium, but since the cadmium price has fallen from $6-7 in 1988-1989 to $2 in 1991, the value of the credit has become fairly minor.

Of the 44 smelters costed in 1991, only 17 receive a by-product credit of over $1 per tonne of zinc. For nine plants, however, the credit exceeds $50.

In 1995 we calculate that 20 of the existing and potential smelters would have by-product credits over $10. The potential ISFs in New Brunswick, Thailand and Japan would be the only new plants in this group. Of the 20 gaining significant credits, 11 would be ISFs. The other nine would be the five Japanese electrolytic smelters, Overpelt, Clarksville, Asturiana and Trail. Ten smelters would have by-product metal credits of $70 or more. The metal prices used to calculate by-product credits are as follows:

	1991	1995
Lead (c/lb)	27.6	41.2
Gold ($/toz)	365.0	410.0
Silver ($/toz)	4.0	4.4
Cadmium ($/lb)	2.0	1.7
Germanium ($/tg)	345.0	405.6

The detailed market forecasts for lead and copper are contained in appendices F and G, respectively. Our assumptions for the precious metals market has been provided with the assistance of the CPM Group in New York which specializes in the gold, silver and platinum-group-metal industries. The cadmium and germanium market forecasts have been generated with the assistance of producers, consumers and other knowledgeable experts in these industries.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING BY-PRODUCT METAL CREDIT IN 1991

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Samim ISF	(86.8)	63.0	63.0	1.3
2	Harima	(81.3)	67.2	130.2	2.6
3	Hachinohe	(79.1)	85.8	216.0	4.4
4	Annaka	(76.3)	105.6	321.6	6.5
5	Hikoshima	(76.3)	52.1	373.7	7.6
6	Kamioka	(76.3)	54.0	427.7	8.6
7	Akita	(76.3)	84.4	512.1	10.3
8	Iijima	(76.3)	152.9	665.0	13.4
9	Noyelles	(57.1)	86.1	751.1	15.2
10	Chanderija	(42.2)	28.0	779.1	15.7
11	Avonmouth	(32.6)	99.0	878.1	17.7
12	Overpelt	(30.8)	90.0	968.1	19.6
13	Cockle Creek	(23.9)	72.0	1040.1	21.0
14	Duisburg	(23.2)	95.0	1135.1	22.9
15	Clarksville	(17.5)	95.5	1230.6	24.9
16	A de Zinc	(13.1)	249.2	1479.8	29.9
17	Trail	(8.4)	275.5	1755.3	35.5
18	La Oroya	(0.8)	63.5	1818.8	36.7
19	Potosi	(0.6)	90.4	1909.2	38.6
20	Torreon	(0.6)	103.5	2012.7	40.7
21	Paedang	(0.6)	71.0	2083.7	42.1
22	Auby-Douai	(0.4)	178.4	2262.1	45.7
23	Samim Elec	(0.4)	78.4	2340.5	47.3
24	Sauget	(0.4)	75.8	2416.3	48.8
25	Budel	(0.3)	210.0	2626.3	53.1
26	Crotone	(0.3)	99.0	2725.3	55.1
27	Juiz Fora	(0.3)	57.6	2782.9	56.2
28	Kokkola	(0.3)	168.3	2951.2	59.6
29	Bartlesville	(0.3)	50.0	3001.2	60.6
30	Nordenham	(0.3)	126.0	3127.2	63.2
31	Onsan	(0.3)	178.2	3305.4	66.8
32	Balen	(0.2)	171.0	3476.4	70.2
33	Kidd Creek	(0.2)	131.0	3607.4	72.9
34	Cajamarquilla	(0.2)	66.3	3673.7	74.2
35	Kolwezi	(0.2)	27.0	3700.7	74.8
36	Norzink	(0.2)	128.8	3829.5	77.4
37	Datteln	(0.1)	170.0	3999.5	80.8
38	Valleyfield	(0.1)	211.6	4211.1	85.1
39	Tres Marias	(0.1)	69.1	4280.2	86.5
40	Itaguai	(0.1)	41.6	4321.8	87.3
41	Risdon	(0.1)	198.0	4519.8	91.3
42	Flin Flon	(0.1)	73.1	4592.9	92.8
43	Sulfacid	(0.1)	31.4	4624.2	93.4
44	S Africa	0	90.0	4714.2	95.3
45	Not Costed	0	235.0	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING BY-PRODUCT METAL CREDIT IN 1995

	PRODUCTION		CUMULATIVE	
	$/TONNE	(000T)	TOTAL	PERCENT
1 Samim ISF	(109.2)	63.0	63.0	1.0
2 Harima	(100.8)	67.2	130.2	2.1
3 Hachinohe	(97.4)	85.8	216.0	3.4
4 Akita	(89.1)	84.4	300.4	4.8
5 Annaka	(89.1)	105.6	406.0	6.5
6 Hikoshima	(89.1)	52.1	458.1	7.3
7 Kamioka	(89.1)	58.3	516.4	8.2
8 Iijima	(89.1)	152.9	669.3	10.6
9 Noyelles	(70.0)	86.1	755.4	12.0
10 Thai ISF	(66.9)	57.0	812.4	12.9
11 Tomakomai	(57.0)	114.0	926.4	14.7
12 Chanderija	(56.1)	66.5	992.9	15.8
13 Avonmouth	(46.1)	99.0	1091.9	17.4
14 Overpelt	(36.2)	90.0	1181.9	18.8
15 Cockle Creek	(30.7)	72.0	1253.9	19.9
16 Duisburg	(29.8)	95.0	1348.9	21.5
17 Clarksville	(20.6)	95.5	1444.5	23.0
18 NB ISF	(18.6)	95.0	1539.5	24.5
19 A de Zinc	(15.3)	306.9	1846.4	29.4
20 Trail	(10.0)	287.1	2133.5	33.9
21 La Oroya	(1.0)	66.2	2199.7	35.0
22 Torreon	(0.7)	174.6	2374.3	37.8
23 Potosi	(0.7)	90.4	2464.7	39.2
24 Paedang	(0.5)	71.0	2535.7	40.3
25 Samim Elec	(0.4)	78.4	2614.1	41.6
26 Auby-Douai	(0.4)	178.4	2792.5	44.4
27 Sauget	(0.4)	75.8	2868.3	45.6
28 Budel	(0.4)	210.0	3078.3	49.0
29 Crotone	(0.3)	99.0	3177.3	50.5
30 Juiz Fora	(0.2)	60.0	3237.3	51.5
31 Kokkola	(0.2)	168.3	3405.6	54.2
32 Bartlesville	(0.2)	50.0	3455.6	55.0
33 Nordenham	(0.2)	126.0	3581.6	57.0
34 Onsan	(0.2)	198.0	3779.6	60.1
35 Balen	(0.2)	171.0	3950.6	62.8
36 Kidd Creek	(0.2)	131.0	4081.6	64.9
37 NB Elec	(0.2)	152.0	4233.6	67.3
38 France Elec	(0.1)	152.0	4385.6	69.8
39 Indo Elec	(0.1)	152.0	4537.6	72.2
40 Japan Elec	(0.1)	152.0	4689.6	74.6
41 Austr Elec	(0.1)	152.0	4841.6	77.0
42 Cajamarquilla	(0.1)	76.5	4918.1	78.2
43 Kolwezi	(0.1)	21.6	4939.7	78.6
44 Norzink	(0.1)	133.0	5072.7	80.7
45 Datteln	(0.1)	178.0	5250.7	83.5
46 Valleyfield	(0.1)	218.5	5469.2	87.0
47 Tres Marias	(0.1)	69.1	5538.3	88.1
48 Itaguai	(0.1)	93.5	5631.8	89.6
49 Risdon	(0.1)	198.0	5829.8	92.7
50 Flin Flon	(0.1)	76.1	5905.9	93.9
51 Sulfacid	(0.1)	31.4	5937.3	94.4
52 Not Costed	0	260.0	6197.3	98.6
53 S Africa	0	90.0	6287.3	100.0

II.2.7 Transportation Costs

This is a minor cost consideration for most smelters. European, Japanese and North American smelters sell almost all of their production in their own region and transport costs run in the range of $15-40/tonne.

However, some of the smelters located in zinc mining regions with underdeveloped domestic markets can incur significant costs in exporting their metal to distant customers. The Peruvian smelters must absorb costs of about $100/tonne, while the Kowezi smelter in Zaire incurs a cost of about $117.

In 1995, the eight potential new smelters would have transport costs ranging from a low of $27 for Japan and France to a high of $56-59 for Queensland and New Brunswick.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING TRANSPORT COSTS IN 1991

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	235.0	235.0	4.7
2	Paedang	13.9	71.0	306.0	6.2
3	Akita	14.6	84.4	390.4	7.9
4	Annaka	14.6	105.6	496.0	10.0
5	Hikoshima	14.6	52.1	548.1	11.1
6	Kamioka	14.6	54.0	602.1	12.2
7	Iijima	14.6	152.9	755.0	15.3
8	Crotone	14.9	99.0	854.0	17.3
9	Onsan	16.3	178.2	1032.2	20.9
10	Datteln	19.7	170.0	1202.2	24.3
11	Duisburg	19.7	95.0	1297.2	26.2
12	Nordenham	19.7	126.0	1423.2	28.8
13	Norzink	19.9	128.8	1552.0	31.4
14	Samim ISF	20.6	63.0	1615.0	32.6
15	Kokkola	20.6	168.3	1783.3	36.0
16	Samim Elec	22.4	78.4	1861.7	37.6
17	Balen	22.6	171.0	2032.7	41.1
18	Overpelt	22.6	90.0	2122.7	42.9
19	Auby-Douai	22.6	178.4	2301.1	46.5
20	Budel	22.6	210.0	2511.1	50.7
21	S Africa	22.6	90.0	2601.1	52.6
22	Noyelles	22.6	86.1	2687.2	54.3
23	Avonmouth	23.1	99.0	2786.2	56.3
24	Hachinohe	23.1	85.8	2872.0	58.0
25	Harima	28.2	67.2	2939.2	59.4
26	Torreon	28.6	103.5	3042.7	61.5
27	Itaguai	31.3	41.6	3084.2	62.3
28	Clarksville	32.3	95.5	3179.8	64.2
29	Juiz Fora	35.4	57.6	3237.4	65.4
30	Cockle Creek	35.7	72.0	3309.4	66.9
31	Kidd Creek	37.1	131.0	3440.4	69.5
32	Sauget	38.4	75.8	3516.2	71.0
33	Potosi	39.7	90.4	3606.6	72.9
34	Bartlesville	42.0	50.0	3656.6	73.9
35	Tres Marias	42.8	69.1	3725.7	75.3
36	Valleyfield	45.7	211.6	3937.3	79.6
37	Sulfacid	46.9	31.4	3968.7	80.2
38	A de Zinc	53.6	249.2	4217.9	85.2
39	Risdon	55.9	198.0	4415.9	89.2
40	Chanderija	79.0	28.0	4443.9	89.8
41	Flin Flon	81.3	73.1	4516.9	91.3
42	Trail	87.2	275.5	4792.4	96.8
43	Cajamarquilla	95.6	66.3	4858.7	98.2
44	La Oroya	98.9	63.5	4922.2	99.5
45	Kolwezi	117.1	27.0	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING TRANSPORT COSTS IN 1995

			PRODUCTION	CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	260.0	260.0	4.1
2	Paedang	12.1	71.0	331.0	5.3
3	Hikoshima	17.2	52.1	383.1	6.1
4	Annaka	17.2	105.6	488.7	7.8
5	Kamioka	17.2	58.3	547.0	8.7
6	Akita	17.2	84.4	631.4	10.0
► 7	Iijima	17.2	152.9	784.3	12.5
► 8	Onsan	19.2	198.0	982.3	15.6
9	Norzink	19.7	133.0	1115.3	17.7
10	Samim ISF	21.3	63.0	1178.3	18.7
11	Samim Elec	23.1	78.4	1256.7	20.0
12	Duisburg	23.3	95.0	1351.7	21.5
13	Datteln	23.3	178.0	1529.7	24.3
14	Nordenham	23.3	126.0	1655.7	26.3
15	Crotone	24.2	99.0	1754.7	27.9
16	Budel	26.6	210.0	1964.7	31.2
17	Overpelt	26.6	90.0	2054.7	32.7
18	Balen	26.6	171.0	2225.7	35.4
19	S Africa	26.6	90.0	2315.7	36.8
20	Noyelles	26.6	86.1	2401.8	38.2
21	Auby-Douai	26.6	178.4	2580.2	41.0
► 22	Japan Elec	26.6	152.0	2732.2	43.5
► 23	France Elec	26.6	152.0	2884.2	45.9
24	Avonmouth	27.4	99.0	2983.2	47.4
25	Hachinohe	27.4	85.8	3069.0	48.8
► 26	Thai ISF	30.2	57.0	3126.0	49.7
► 27	Tomakomai	33.6	114.0	3240.0	51.5
28	Harima	33.6	67.2	3307.2	52.6
► 29	Torreon	33.9	174.6	3481.8	55.4
30	Kokkola	35.0	168.3	3650.1	58.1
31	Itaguai	37.1	93.5	3743.6	59.5
32	Clarksville	38.2	95.5	3839.1	61.1
► 33	Juiz Fora	42.3	60.0	3899.1	62.0
► 34	Indo Elec	43.3	152.0	4051.1	64.4
35	Kidd Creek	44.0	131.0	4182.1	66.5
36	Sauget	45.9	75.8	4258.0	67.7
37	Potosi	47.5	90.4	4348.4	69.2
38	Bartlesville	49.7	50.0	4398.3	70.0
39	Tres Marias	51.2	69.1	4467.5	71.1
► 40	Australia Elec	55.6	152.0	4619.5	73.5
41	Sulfacid	55.6	31.4	4650.8	74.0
► 42	NB Elec	59.4	152.0	4802.8	76.4
► 43	NB ISF	59.4	95.0	4897.8	77.9
► 44	Valleyfield	61.3	218.5	5116.3	81.4
45	Cockle Creek	63.1	72.0	5188.3	82.5
► 46	A de Zinc	80.5	306.9	5495.2	87.4
47	Chanderija	94.9	66.5	5561.7	88.5
48	Flin Flon	96.7	76.1	5637.8	89.7
► 49	Risdon	102.1	198.0	5835.8	92.8
► 50	Trail	103.7	287.1	6122.9	97.4
51	Kolwezi	155.8	21.6	6144.5	97.7
► 52	Cajamarquilla	163.8	76.5	6221.0	98.9
53	La Oroya	167.7	66.2	6287.3	100.0

II.2.8 Net Operating Costs

The range of net operating costs for existing plants in 1991 is from $373/tonne all the way up to $2,116. The costs of some of the smelters at the top of the curve have been badly distorted by governmental exchange control policies aimed at curbing breakaway inflation. These are the smelters in Argentina, Peru and Brazil.

The smelters that treat silicate ores and must buy in sulfur are also high cost. These plants include Tres Marias and Itaguai in Brazil and Paedang in Thailand. The Kolwezi smelter in Zaire is high cost because of its remote location.

The Italian smelters are also very high cost because of very high electricity tariffs, over-manning and general plant and equipment inefficiencies.

After these facilities, the highest cost smelter is Overpelt in Belgium at $736. This is an old and inefficient smelter and plans had been drawn up to close Overpelt while expanding Balen. These plans have now been indefinitely postponed because of the collapse in zinc prices.

Trail has the lowest net operating cost at $373. This smelter enjoys economies of scale at 290,000 tpy and low electricity costs. The second lowest cost smelter is Asturiana, followed by Risdon, Valleyfield and Budel. All of these smelters have capacities of over 200,000 tpy and their input costs reflect the economies of scale. The operating cost range of these four smelters is $382-405.

Both Mexican smelters are low cost, with Torreon at $414 and San Luis Potosi at $425. They combine low labor and electricity costs with a reasonably good sulfur credit. The Korean smelter at Onsan ranks next at $443.

With the exception of Budel in the Netherlands, the lowest cost European smelters are Auby and Norzink at $449. This places them in the lower half of the cost curve. Those falling in the third highest quartile are Datteln, Kokkola, Avonmouth, Nordenham and Balen. The Noyelles and Duisburg ISFs fall at about the eightieth percentile, reflecting high wages and a higher labor input per tonne of zinc produced with the ISF process.

The Japanese costs range from $410 at the Hachinohe ISF to $677 at Hikoshima and $692 at Kamioka. These latter smelters are both small and this results in high unit cost inputs.

Of the other two Canadian smelters, Kidd Creek is low cost at $446, while Flin Flon is fairly high cost at $624. Flin Flon is now undergoing a modernization program which will bring its costs down somewhat.

In the US, Clarksville is low cost at $479. It is the newest and largest US plant. Sauget comes in at $591, while the small Bartlesville smelter is the highest cost at $658.

The 1995 cost schedule includes the eight planned or potential smelters, raising the number of smelters with estimated costs to 52. The Indonesian smelter would rank as the lowest cost at $313. Its major assets would be low cost labor and a good sulfuric acid market.

The Torreon smelter, at $335, would improve its ranking to second as a result of a capacity expansion. The new French smelter would have the third lowest operating cost at $394, owing to maximum operating efficiencies from the most modern equipment and a good electricity rate.

Other smelters with 1995 net operating costs below $500 would be Trail, Asturiana, Valleyfield, the new Japanese ISF at Tomakomai, the Chanderija ISF in India, San Luis Potosi, the new electrolytic smelters in Australia and New Brunswick, Risdon and Kidd Creek.

At the top of the cost curve are the Italian smelters, and the Argentine and Zaire smelters. These latter plants are very small and incur a scale penalty.

Overpelt, assuming it is still operating in 1995, would be the only other smelter with net operating costs above $900.

Of the other planned or potential smelters, the Thai ISF would come in at $559 and the New Brunswick ISF at $600. The Japanese electrolytic smelter would be the highest cost at $663. We have probably been unfair in our by-product credit assumption for this plant. To facilitate comparisons among the potential new smelters, we assumed they would all recover some cadmium and 95 percent of the sulfur contained in concentrate. The sulfuric acid net back price would, of course, differ from plant to plant.

We did not assign credits for any other metal by-products, but we did give the Japanese smelter a $4/tonne credit for gypsum. In reality, all of the Japanese electrolytic smelters capture other by-product metals and receive a by-product metals credit of about $90 in 1995. Were we to assume the same credits for the hypothetical Japanese smelter, its net operating cost would fall from $663 to $573 and it would drop from the seventy-eighth to the fifty-eighth percentile.

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING NET OPERATING COSTS IN 1991

	PRODUCTION		CUMULATIVE	
	$/TONNE	(000T)	TOTAL	PERCENT
1 Not Costed	0	235.0	235.0	4.7
2 Trail	373.1	275.5	510.5	10.3
3 A de Zinc	381.8	249.2	759.7	15.3
4 Risdon	388.5	198.0	957.7	19.4
5 Valleyfield	389.4	211.6	1169.3	23.6
6 Budel	404.6	210.0	1379.3	27.9
7 S Africa	406.9	90.0	1469.3	29.7
8 Hachinohe	409.8	85.8	1555.1	31.4
9 Torreon	414.1	103.5	1658.6	33.5
10 Potosi	424.8	90.4	1749.0	35.3
11 Onsan	442.5	178.2	1927.2	38.9
12 Kidd Creek	445.8	131.0	2058.3	41.6
13 Auby-Douai	448.7	178.4	2236.6	45.2
14 Norzink	448.8	128.8	2365.4	47.8
15 Clarksville	479.3	95.5	2461.0	49.7
16 Datteln	482.2	170.0	2631.0	53.2
17 Cockle Creek	496.6	72.0	2703.0	54.6
18 Iijima	499.9	152.9	2855.8	57.7
19 Kokkola	523.1	168.3	3024.1	61.1
20 Harima	525.8	67.2	3091.3	62.5
21 Paedang	548.5	71.0	3162.3	63.9
22 Avonmouth	553.7	99.0	3261.3	65.9
23 Nordenham	555.6	126.0	3387.3	68.4
24 Balen	557.7	171.0	3558.3	71.9
25 Chanderija	567.0	28.0	3586.3	72.5
26 Juiz Fora	582.9	57.6	3643.9	73.6
27 Sauget	590.5	75.8	3719.7	75.2
28 Annaka	591.1	105.6	3825.4	77.3
29 Flin Flon	623.9	73.1	3898.4	78.8
30 Akita	627.6	84.4	3982.8	80.5
31 Noyelles	641.2	86.1	4068.9	82.2
32 Duisburg	655.2	95.0	4163.9	84.1
33 Bartlesville	658.2	50.0	4213.9	85.1
34 Hikoshima	677.2	52.1	4265.9	86.2
35 Kamioka	691.6	54.0	4319.9	87.3
36 Overpelt	736.2	90.0	4409.9	89.1
37 Itaguai	760.9	41.6	4451.5	89.9
38 Tres Marias	765.8	69.1	4520.6	91.3
39 Samim ISF	792.4	63.0	4583.6	92.6
40 Kolwezi	824.6	27.0	4610.6	93.2
41 Samim Elec	919.8	78.4	4689.1	94.7
42 Cajamarquilla	1046.2	66.3	4755.4	96.1
43 Crotone	1141.7	99.0	4854.4	98.1
44 La Oroya	1337.8	63.5	4917.9	99.4
45 Sulfacid	2115.6	31.4	4949.2	100.0

RANKING OF MAJOR ZINC SMELTERS IN ORDER OF INCREASING NET OPERATING COSTS IN 1995

		PRODUCTION		CUMULATIVE	
		$/TONNE	(000T)	TOTAL	PERCENT
1	Not Costed	0	260.0	260.0	4.1
►2	Indo Elec	312.5	152.0	412.0	6.6
►3	Torreon	334.9	174.6	586.6	9.3
►4	France Elec	394.4	152.0	738.6	11.7
►5	Trail	396.2	287.1	1025.7	16.3
►6	A de Zinc	396.3	306.9	1332.6	21.2
►7	Valleyfield	414.5	218.5	1551.1	24.7
►8	Tomakomai	418.8	114.0	1665.1	26.5
9	Chanderija	432.3	66.5	1731.6	27.5
10	Potosi	440.5	90.4	1822.0	29.0
►11	Australia Elec	449.8	152.0	1974.0	31.4
►12	NB Elec	459.9	152.0	2126.0	33.8
►13	Risdon	475.1	198.0	2324.0	37.0
14	Kidd Creek	480.3	131.0	2455.0	39.0
15	Norzink	504.9	133.0	2588.0	41.2
16	S Africa	506.8	90.0	2678.0	42.6
►17	Onsan	511.1	198.0	2876.0	45.7
18	Budel	514.1	210.0	3086.0	49.1
19	Hachinohe	519.0	85.8	3171.9	50.4
►20	Juiz Fora	532.5	60.0	3231.9	51.4
21	Itaguai	536.7	93.5	3325.4	52.9
22	Clarksville	548.1	95.5	3420.9	54.4
►23	Thai ISF	559.1	57.0	3477.9	55.3
24	Datteln	572.3	178.0	3655.9	58.1
25	Auby-Douai	577.4	178.4	3834.3	61.0
26	Cockle Creek	587.6	72.0	3906.3	62.1
►27	NB ISF	599.7	95.0	4001.3	63.6
►28	Iijima	601.6	152.9	4154.1	66.1
29	Avonmouth	621.4	99.0	4253.1	67.6
30	Kokkola	622.7	168.3	4421.4	70.3
31	Flin Flon	636.8	76.1	4497.6	71.5
32	Paedang	640.1	71.0	4568.6	72.7
33	Nordenham	649.5	126.0	4694.6	74.7
34	Harima	658.4	67.2	4761.7	75.7
►35	Japan Elec	663.3	152.0	4913.7	78.2
►36	Cajamarquilla	669.3	76.5	4990.2	79.4
37	Balen	685.6	171.0	5161.2	82.1
38	Tres Marias	689.1	69.1	5230.3	83.2
39	Sauget	695.4	75.8	5306.2	84.4
40	Annaka	712.1	105.6	5411.8	86.1
41	Akita	757.4	84.4	5496.2	87.4
42	Bartlesville	772.9	50.0	5546.2	88.2
43	Noyelles	814.5	86.1	5632.3	89.6
44	Kamioka	819.0	58.3	5690.6	90.5
45	Hikoshima	820.1	52.1	5742.7	91.3
46	Duisburg	825.1	95.0	5837.7	92.8
47	La Oroya	860.7	66.2	5903.9	93.9
48	Overpelt	907.8	90.0	5993.9	95.3
49	Samim ISF	945.3	63.0	6056.9	96.3
50	Kolwezi	1037.9	21.6	6078.5	96.7
51	Sulfacid	1041.4	31.4	6109.8	97.2
52	Samim Elec	1058.8	78.4	6188.3	98.4
53	Crotone	1321.3	99.0	6287.3	100.0

II.3 Capital Costs For Greenfield Smelters

In this section we will develop estimates of the capital costs for five greenfield electrolytic zinc smelters and three Imperial Smelting Furnace (ISF) smelters. The electrolytic smelters would all have a capacity of 160,000 tpy of slab and would be located in France, New Brunswick, Indonesia, Queensland and Japan. The ISF smelters would not all be of the same capacity because two of them have already had their capacities determined by feasibility studies. These are a 120,000 tpy zinc and 60,000 lead smelter in Japan and a 60,000 tpy zinc and 40,000 tpy lead plant in Thailand. The third ISF we will simulate is a 100,000 tpy zinc and 40,000 tpy lead smelter in New Brunswick. This capacity reflects an assumed availability of bulk concentrates in the province.

Before turning to these potential projects we will explain the methodology used in developing our capital cost estimates. We will present a full explanation using an electrolytic smelter and then describe any variations in costing ISF plants.

The forecasting algorithms were developed on the basis of costs in the US in 1985. For a 160,000 tpy electrolytic zinc smelter the cost per tonne of capacity in the US in 1985 is $2,713. All of the greenfield plants are assumed to be custom smelters, meaning equipment has to be included for concentrate unloading, storage and blending. A smelter dedicated to treating the concentrates of a single mine and located at the mine site would not need this equipment and would incur a savings of 8.5 percent in its capital costs. The smelters under consideration in this study are all assumed to take concentrates from more than one mine and would not receive this "integrated smelter" cost reduction.

The 1985 US base case smelter incorporates stringent environmental controls. We call this Environmental Class I. Smelters that do not incorporate this degree of environmental controls are less costly to build. Thus, we assign discounts according to the leniency of environmental controls. Smelters in Environmental Class II receive a 2 percent discount. Those in Environmental Class III receive an 8 percent discount and those in Environmental Class IV (no controls) receive a 12 percent discount. We assume all of the greenfield smelters under consideration in this study would be in Class I or II.

The next step is to estimate what the 1985 cost would be in countries other than the US. In 1985 the US dollar was very over-valued against most other currencies compared with prior and subsequent exchange rate values. This means that it would have cost more to build a smelter in the US in 1985 than in almost any other country, based strictly on currency values.

To deal with this complex issue, RSI has developed a relative competitive cost index. The index measures the combined effect of exchange rates and relative inflation rates.

Our analysis has determined that it is simplistic to assume that the difference in inflation rates between two countries will be offset by a corresponding adjustment in the exchange rate of the two currencies. For example, the simplistic assumption would be that if inflation in the United Kingdom is 8 percent per annum compared with 5 percent per annum in the US, the pound will, over time, devalue against the US dollar by approximately 3 percent per annum. In reality, this situation does not occur. Even from a theoretical standpoint, it is not clear that purchasing power parity, which is essentially the foundation of the above assumption, is a workable theory for the explanation of movements in exchange rates. At best, it applies only to the current account of the balance of payments, not to the capital account, and in recent years, international capital movements have exerted a dominant influence on exchange rates.

Moreover, even if purchasing power parity were a valid way for proceeding from the theoretical standpoint, it would not necessarily be applicable to the metals and minerals industry. The primary reason for this is that the mixture of costs involved in a typical mining and metals operation is quite different from the representative "basket of goods" in the economy as a whole. Specifically, the metals and minerals industry is likely to make far more intensive use of capital and energy resources and transportation services than the economy as a whole, and proportionally less use of various kinds of business and personal services. Both from the theoretical and practical standpoints, therefore, it is safe to conclude that there is no real reason why exchange rate changes should serve to offset relative inflation rates. Indeed, an examination of past data reveals precisely that this has not been the case.

The capital relative cost index we have developed assigns a value of 1.0 to the US in 1985, since this is the base year used in developing our capital cost algorithms. We found we could not develop a simple index in which we would assign all countries a 1985 index value of 1.0 and simply measure changes since 1985. This is because the dollar was very over-valued in 1985 and the competitive position of US industry was extremely poor. Thus, it would have been very misleading for an index which assumed parity in 1985.

In fact, we found that there simply is no good base year to capture "normal" exchange rate values across all currencies. Therefore, we reviewed the exchange rate/inflation performance for each country prior to 1985 and assigned each a different 1985 value against the US value of 1.0.

For all of the major industrial countries the 1985 index value is less than 1.0. The value for Japan is 0.86, for Germany 0.80 and for Canada 0.96. For countries in the developing world, most have a 1985 index value closer to 1.0. This means that in the five to eight years leading up to 1985, the US competitive position deteriorated significantly against its main industrial competitors but not appreciably against most developing countries. Exceptions to the latter are the strongly emerging economies, such as Korea and Taiwan, which have 1985 index values of 0.77 and 0.84, respectively.

What this means in terms of zinc smelters is that while the capital cost per tonne of electrolytic capacity in the US in 1985 was $2,713, the exact same smelter could have been built in Japan at a cost of $2,333/tonne, in Germany for $2,170/tonne and in Canada for $2,604/tonne.

In extending the index forward from 1985 we find that the US competitive position improved rapidly as the dollar weakened against all major currencies. By 1991 the index for Japan has risen to 1.32, for Germany to 1.19 and for Canada to 1.23. This does not mean that in 1991 it would cost 19 percent more to build a smelter in Germany than in the US, because in 1985 it would have cost 20 percent less to build the smelter in Germany. In other words, the German competitive advantage enjoyed in 1985 had disappeared by 1991 and the cost of building a zinc smelter in either country would be about the same. For Japan, the 14 percent advantage in 1985 has been more than offset by 1991 when the index reached 1.32. Thus, it would be more expansive in dollar terms to build a zinc smelter in Japan in 1991 than in the US. The same would be true in Canada where the index has risen from 0.96 in 1985 to 1.23 in 1991.

Based on our forecasts of inflation rates and exchange rates we can project the index into the future. How this is done is, first, we take a local "basket of goods and services" in any given year and convert the cost of that basket into US dollars at the prevailing exchange rate for that year. Second, for all future years we then recalculate the cost of the local "basket of goods and services" in local currency terms by applying the relevant inflation rate, usually the gross domestic product deflator. For each future year, we again convert the resulting local currency values into US dollars at the relevant exchange rates. As a result of these two steps, we have constructed a price series for the local "basket of goods and services" in US dollars. This price series can be compared directly with the US GDP deflator. By dividing the series by the US GDP deflator, we create an index of the real cost of the "basket of goods and services" in constant 1985 US dollars.

Thus, we can now take the 1985 zinc smelter capital cost for each country and project that to 1995 to account for the relative change in competitiveness versus the US from 1985 to 1995.

The next step is to add a capital cost location penalty where applicable. Again, the base is the US. In developing countries or in remote regions it will cost more to build a plant because of the added expense of transporting equipment to the site. Thus, for example, the Indonesian project is assigned a penalty of 3 percent to cover that added expense. Smelters built in industrially developed regions are not assigned any penalty.

The final calculation to produce a 1995 estimate of capital costs is to add an inflation factor to the cost of new plant and equipment from 1985 to 1995. We do not use a broad-based inflation indicator, such as the consumer price index or the GDP deflator, but instead we have developed an inflation index for heavy industrial plant and equipment. This index has a value of 1.0 in 1985. The forecast index value for 1995 is 1.3632.

The procedure for estimating capital costs for ISF smelters is the same, but a few points must be noted. Industry practice is to assign all costs to the zinc production for ISFs. This produces a higher capital cost per tonne than if the total capital cost were apportioned per tonne of zinc and lead metal produced.

For our ISF calculations we must also deal with a scale factor. As noted above, all of the electrolytic smelters costed were assumed to have a capacity of 160,000 tpy. This is the base case capacity in our algorithm, so no scale adjustment is needed. The ISFs will have zinc capacities of 120,000 tpy in Japan, 100,000 tpy in New Brunswick and 60,000 tpy in Thailand.

The base case capacity for ISFs is 70,000 tpy and the 1985 US dollar value is $2,254/tonne. A scale factor is then assigned to plants with capacities different from the base case of 70,000 tpy. For plants with capacities larger than the base case the scale factor is less than one. For plants smaller than the base case the scale factor is greater than one. The base case dollar cost per tonne is then multiplied by the scale factor.

After developing these capital cost estimates per tonne of capacity, we must convert these numbers into annual capital costs per tonne of production. This would be the first step in developing full production cost estimates for the smelters. By full production cost we mean the capital repayment cost, plus the net operating cost, plus a cost to cover corporate overhead charges.

The capital repayment cost assumes a 15 year debt period at an interest rate of LIBOR plus 3 percent. This interest rate is based on the assumption that two thirds to three quarters of the capital cost would be debt and one quarter to one third would be equity. For a major corporation, the debt would be incurred at LIBOR. The equity investment is valued at an opportunity cost of 20 percent. This opportunity cost is the target rate of return most mining and metals companies require for equity investment. With three quarters debt at a LIBOR rate of 8 percent and one quarter equity at an opportunity cost of 20 percent, the weighted average "interest cost" would be 11 percent, or 3 percent above LIBOR. Obviously, there will be some variation in this formula, but we feel LIBOR plus 3 percent is a reasonable number to use in our cost simulations.

We have already explained how the net operating cost is calculated. A corporate charge is included in our full cost calculation since the expense of corporate cost centers must be carried by corporate profit centers. This corporate overhead charge can vary quite widely. For metals companies with major exploration and research and development programs, these corporate expenses can be quite large. For companies that only operate a single smelter and have no exploration or R & D programs, these corporate charges can be quite modest. For the sake of our calculations we have assumed the same corporate overhead charge for each smelter -- $2.96 Mn in 1995. Thus, the only variation in this charge on a tonne of production basis would be due to the capacities of the plants.

The sum of these three elements is the full cost of production. One important point to remember is that the annualized capital cost incorporates a profit -- or a return on the equity investment. Thus, the "full cost" numbers calculated are higher than "break even" production costs. They are, in actuality, revenue targets needed to cover costs and to produce a target rate of return on invested equity.

The following tables set forth the calculations to derive the capital cost per tonne of each of the potential greenfield smelters. Our smelter cost model does not calculate capital costs in exactly this manner. The scale factor is incorporated in the equation that calculates the 1985 base. We have broken this out as a separate step in these tables so that the build up of costs is easier to follow.

These tables also show how the full cost per tonne of production is built up from the annualized capital cost, the net operating cost and the corporate charge. The final table carries the full cost buildup for all eight facilities.

Of the five electrolytic projects, Indonesia comes in as the lowest cost. This is due to a very low operating cost, which, in turn, reflects low cost labor and a good sulfur credit. This plant would be tied into a local fertilizer plant and would receive a high net back price for its acid.

The Queensland smelter would rank second lowest primarily because of our assumptions for the Australian capital relative cost index. The index was low in 1985 at 0.82 and rises to only 1.11 in 1995. By comparison, the French index was also low in 1985 at 0.84, but it rises to 1.31 in 1995.

The French smelter would rank as third lowest because of low operating costs. This reflects a good electricity rate and sulfur credit. The New Brunswick smelter would be a bit higher cost than the French smelter primarily because of a lower sulfur credit. The assumption is that there would not be a local acid market and the shipping costs to acid consumers would be quite high.

The Japanese smelter would be the highest cost by far. We already mentioned that we treated all five electrolytic smelters the same in terms of by-product metal credits. If the hypothetical Japanese smelter recovered all of the by-product metals that, for example, the Iijima smelter recovers, its net operating costs in 1995 would be about $90 lower. It would still be the highest cost of the five smelter projects by a wide margin. Electricity and labor costs are very high in Japan and the capital relative cost index would have risen from 0.86 in 1985 to a forecast level of 1.39 in 1995.

Of the three ISF facilities costed, the Japanese smelter would be the lowest. Since plans for this smelter have already been formulated, we have assumed a typical Japanese by-product recovery credit. This smelter is the largest of the ISFs we have costed and it would enjoy significant economies of scale, both in capital and operating costs. Also, as an ISF it would not be seriously disadvantaged by high Japanese electricity costs.

The New Brunswick ISF would rank second. As with the New Brunswick electrolytic smelter, it would receive a modest sulfur credit. The Thai ISF would be the highest cost. It would be the smallest of the three and would suffer scale penalties in both capital and operating costs.

A comparison worth making is the full cost of the potential smelters with the net operating costs of existing smelters. The logic behind this comparison is that existing facilities will continue to operate as long as they can cover their operating costs, whereas investors in new plants must concern themselves with covering their operating costs and repaying their debt.

To acheive a reasonable degree of security, investors normally want their full costs not to exceed the operating costs of facilities in the eightieth to eighty-fifth percentile. This would mean a full cost no higher than about $700.

None of the eight projects can meet this test. The lowest cost, i.e. the Japanese ISF would have total costs in the ninety-fifth percentile of the 1995 net operating cost schedule. Only the three smelters in Italy and those in Argentina and Zaire would have net operating costs above Tomakomai's full cost.

NEW BRUNSWICK ELECTROLYTIC

	1985	1995
U.S. Base 2713		
Concentrate Grade Adjustment (1)	2797	
Environmental Class Adjustment (0)	2797	
Capital Relative Cost Index	0.96	1.19
Adjusted Cost Base	2683	3342
Location penalty (0)	2683	
Cost inflation (36.23%)		4553
Capital cost/tonne	2683	4553
Annualized Capital Cost		651
Corporate Charge		19
Net Operating Cost		460
Full Cost:		1130

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(1) Larger concentrate treatment capacity needed to achieve 160,000 tpy slab capacity. Assumes 50.6% zinc grade vs. 55% in base case.

FRANCE ELECTROLYTIC

	1985	1995
U.S. Base	2713	
Environmental Class Adjustment (0)	2713	
Capital Relative Cost Index	0.84	1.31
Adjusted Cost Base	2271	3563
Location Penalty (0)	2271	3563
Cost Inflation (36.23%)		4854
Capital cost/tonne	2271	4854
Annualized Capital Cost		695
Corporate Charge		19
Net Operating Cost		394
Full Cost:		1108

INDONESIA ELECTROLYTIC

	1985	1995
U.S. Base	2713	
Environmental Class Adjustment (-2%)	2659	
Capital Relative Cost Index	1.00	1.16
Adjusted Cost Base	2659	3097
Location Penalty (15%)	3058	3561
Cost Inflation (36.23%)		4851
Capital Cost/Tonne	3058	4851
Annualized Capital Cost		693
Corporate Charge		19
Net Operating Cost		313
Full Cost:		1025

QUEENSLAND ELECTROLYTIC

	1985	1995
U.S. Base	2713	
Environmental Class Adjustment (-2%)	2659	
Capital Relative Cost Index	0.82	1.11
Adjusted Cost Base	2188	2947
Location Penalty (3%)	2254	3035
Cost Inflation (36.23%)		4134
Capital Cost/Tonne	2254	4134
Annualized Capital Cost		591
Corporate Charge		19
Net Operating Cost		450
Full Cost:		1060

JAPAN ELECTROLYTIC

	1985	1995
U.S. Base	2713	
Environmental Class Adjustment (0)	2713	
Capital Relative Cost Index	0.86	1.39
Adjusted Cost Base	2330	3780
Location Penalty (0)	2330	3780
Cost Inflation (36.23%)		5149
Capital Cost/Tonne	2330	5149
Annualized Capital Cost		737
Corporate Charge		19
Net Operating Cost		663
Full Cost:		1419

NEW BRUNSWICK ISF

	1985	1995
U.S. Base	2254	
Concentrate Grade Adjustment (1)	2412	
Environmental Class Adjustment (0)		
Scale Factor	0.86	
Scale Adjusted	2074	
Capital Relative Cost Index	0.96	1.19
Adjusted Cost Base	1989	2478
Location Penalty (0)		
Cost Inflation (36.23%)		3376
Capital Cost/Tonne	1989	3376
Annualized Capital Cost		482
Corporate Charge		31
Net Operating Cost		600
Full Cost:		1113

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(1) Larger concentrate treatment capacity needed to match base case zinc production. Assumes 34% grade vs. 46% in base case.

THAILAND ISF

	1985	1991
U.S. Base	2254	
Environmental Class Adjustment (-2%)	2209	
Scale Factor	1.10	
Scale Adjusted	2432	
Capital Relative Cost Index	0.91	1.17
Adjusted Cost Base	2213	2856
Location Penalty (15%)	2542	3285
Cost Inflation (36.23%)		
Capital Cost/Tonne	2542	4475
Annualized Capital Cost		640
Corporate Charge		52
Net Operating Cost		559
Full Cost:		1251

JAPAN ISF

	1985	1995
U.S. Base	2254	
Environmental Class Adjustment (0)	2254	
Scale Factor	0.78	
Scale Adjusted	1760	
Capital Relative Cost Index	0.86	1.39
Adjusted Cost Base	1511	2451
Location Penalty (0)	1511	2451
Cost Inflation (36.23%)		3339
Capital Cost/Tonne	1511	3339
Annualized Capital Cost		477
Corporate Charge		26
Net Operating Cost		419
Full Cost:		922

GREENFIELD ELECTROLYTIC SMELTER PRODUCTION COST

($/tonne metal)

	New Brunswick	France	Indonesia	Queensland	Japan
Annualized Capital Cost	651	695	693	591	737
Corporate Charge	19	19	19	19	19
Net Operating Cost	460	394	313	450	663
Full Cost:	1130	1108	1025	1060	1419

GREENFIELD ISF SMELTER PRODUCTION COST

($/tonne metal)

	New Brunswick	Thailand	Japan
Annualized Capital Cost	482	640	477
Corporate Charge	31	52	26
Net Operating Cost	600	559	419
Full Cost:	1113	1251	922

II.4 Capital Costs For Incremental Expansions

In this section of the report we will examine the cost of incremental expansions at nine existing smelters. These plants are:

- **Valleyfield and Trail in Canada**
- **Torreon in Mexico**
- **Risdon in Australia**
- **Onsan in Korea**
- **Iijima in Japan**
- **Asturiana in Spain**
- **Juiz de Fora in Brazil**
- **Cajamarquilla in Peru**

The amount of the expansion costed will be 100,000 tpy for all but Trail and Iijima. Feasibility studies have already been made for these two smelters and we will use the size of the expansion considered. For Trail this would be 72,000 tpy and for Iijima 84,000 tpy.

In the following tables we will use the same methodology as we used for the greenfield projects. We will build up the capital cost per tonne and then show how the annual full cost of production is built up from the annualized capital cost, the corporate overhead charge and the net operating cost. The tables also show 1991 production costs composed simply of net operating costs and a corporate charge. The final table provides a side-by-side comparison of the nine projects in 1995.

Incremental expansions act to lower unit operating costs through economies of scale. For some of the projects operating costs in 1995 are brought below 1991 levels. For others, cost inflation converted into U.S. dollar terms outweighs the economies of scale and 1995 net operating costs rise above the 1991 level. Because costs are stated in U.S. dollars, local inflation and exchange movements play an important role in determining U.S. dollar denominated operating costs.

Of the nine projects, Torreon has the lowest full production cost at $758. Its annualized capital cost is comparatively high because of its high relative capital cost index, but it has the lowest operating cost.

Valleyfield ranks second in full production costs at $775. The capital component is below average and its operating costs are the second best. Onsan comes in third, with the lowest capital cost per tonne. Operating costs are a bit above average. Its full cost is $793.

Risdon ranks fourth best at $798, with a low capital cost component and about average operating costs. Asturiana has a high capital component due to Spain's high relative capital cost index. Its operating costs are below average and its full cost comes in at $829.

Trail gains the least from economies of scale since this is the smallest expansion costed. However, the operating costs are quite low, so its full cost is $836.

Juiz de Fora suffers from Brazil's high relative capital cost. Despite a low operating cost, its full cost would be $936. Iijima gains less than seven of the other projects on economies of scale since this would be a smaller expansion (84,000 tpy). It also has high operating costs, reflecting the high cost of labor and electricity in Japan. Its full cost would be $988.

The highest cost project would be Cajarmarquilla at $1,134. This reflects Peru's very high relative cost index.

In comparing the full costs of the incremental expansions with the greenfield projects, we see that incremental expansions are much more economical. The full cost of the lowest cost greenfield smelter -- Indonesia -- is $1,025, compared with $757 at Torreon. Only the Cajamarquilla expansion produces a higher full cost than the Indonesian greenfield smelter. However, the best greenfield ISF -- Japan -- would have a lower full cost than three of the incremental expansions -- Juiz de Fora, Iijima and Cajamarquilla. Costs in the following tables are in current dollars per tonne of metal.

In some cases there are different environmental class adjustments in 1985 and 1995. For example, the adjustment may be an 8 percent reduction in 1995 but by 1995 only a 2 percent reduction in capital costs because of increasing stringency in environmental regulations. The notation in the table would appear as follows: (-8% / -2%)

VALLEYFIELD

	1985	1995
U.S. Base	1863	
Scale Factor	1863	
Environment Class Adjustment		
Capital Relative Cost Index	0.96	1.19
Adjusted Cost Base	1788	2216
Location Penalty (0)	1788	2216
Cost Inflation (36.23%)		3019
Capital Cost/Tonne	1788	3019

	1991	1995
Annualized Capital Cost		431.49
Corporate Charge	11.96	9.28
Net Operating Cost	377.92	334.38
Full Cost:	389.88	775.15

TRAIL

	1985	1995
U.S. Base	1863	
Scale Factor (1.12)	2087	
Environmental Class Adjustment (0)	2087	
Capital Relative Cost Index	0.96	1.19
Adjusted Cost Base	2003	2483
Location Penalty (0)	2003	2483
Cost Inflation (36.23%)		3382
Capital Cost/Tonne	2003	3382

	1991	1995
Annualized Capital Cost		483.37
Corporate Charge	9.18	8.25
Net Operating Cost	374.15	344.35
Full Cost:	383.33	835.97

TORREON

	1985	1995
U.S. Base	1863	
Scale Factor	1863	
Environmental Class Adjustment (-8%/0%)	1714	
Capital Relative Cost Index	1.03	1.22
Adjusted Cost Base	1765	2273
Location Penalty (10%)	1942	2500
Cost Inflation (36.23%)		3406
Capital Cost/Tonne	1942	3406

	1991	1995
Annualized Capital Cost		486.80
Corporate Charge	12.28	5.38
Net Operating Cost	345.17	265.30
Full Cost:	357.45	757.48

RISDON

	1985	1995
U.S. Base	1863	
Scale Factor	1863	
Environmental Class Adjustment (0)	1863	
Capital Relative Cost Index	0.82	1.11
Adjusted Cost Base	1528	2068
Location Penalty (0)	1528	2068
Cost Inflation (36.23%)		2818
Capital Cost/Tonne	1528	2818

	1991	1995
Annualized Capital Cost		402.76
Corporate Charge	12.78	9.93
Net Operating Cost	384.62	385.38
Full Cost:	397.40	798.04

ONSAN

	1985	1995
U.S. Base	1863	
Scale Factor (0)	1863	
Environmental Class Adjustment (-2%/0 %)	1826	
Capital Relative Cost Index	0.77	1.05
Adjusted Cost Base	1406	1956
Location Penalty (-10%)	1265	1760
Cost Inflation (36.23%)		2398
Capital Cost/Tonne	1265	2398

	1991	1995
Annualized Capital Cost		342.73
Corporate Charge	7.13	4.97
Net Operating Cost	415.94	445.27
Full Cost:	423.07	792.97

IIJIMA

	1985	1995
U.S. Base	1863	
Scale Factor (1.06)	1975	
Environmental Class Adjustment (0)	1975	
Capital Relative Cost Index	0.86	1.39
Adjusted Cost Base	1699	2746
Location Penalty (-10%)	1529	2471
Cost Inflation (36.23%)		3362
Capital Cost/Tonne	1529	3362

	1991	1995
Annualized Capital Cost		480.51
Corporate Charge	12.42	6.96
Net Operating Cost	476.05	491.15
Full Cost:	488.47	978.62

ASTURIANA

	1985	1995
U.S. Base	1863	
Scale Factor (0)	1863	
Environmental Class Adjustment (-2%/0%)	1826	
Capital Relative Cost Index	0.83	1.32
Adjusted Cost Base	1516	2459
Location Penalty (0)	1516	
Cost Inflation (36.23%)		3350
Capital Cost/Tonne	1516	3350
	1991	1995
Annualized Capital Cost		478.80
Corporate Charge	10.15	7.27
Net Operating Cost	348.58	343.71
Full Cost:	358.73	829.48

JUIZ DE FORA

	1985	1995
U.S. Base	1863	
Scale Factor (0)	1863	
Environmental Class Adjustment (-8% / -2%)	1714	
Capital Relative Cost Index	0.98	1.42
Adjusted Cost Base	1680	2645
Location Penalty (10%)	1848	2910
Cost Inflation (36.23%)		3964
Capital Cost/Tonne	1848	3964
	1991	1995
Annualized Capital Cost		566.55
Corporate Charge	22.05	9.25
Net Operating Cost	554.63	359.70
Full Cost:	576.68	935.50

CAJAMARQUILLA

	1985	1995
U.S. Base	1863	
Scale Factor (0)	1863	
Environmental Class Adjustment (-8% / -2%)	1714	
Capital Relative Cost Index	1.00	1.30
Adjusted Cost Base	1714	2373
Location Penalty (30%)	2228	3086
Cost Inflation (36.23%)		
Capital Cost/Tonne	2228	4203

	1991	1995
Annualized Capital Cost		600.71
Corporate Charge	17.79	8.36
Net Operating Cost	983.17	524.92
Full Cost:	1000.96	1133.99

SMELTER INCREMENTAL EXPANSION PRODUCTION COST

(\$/tonne metal)

	Valleyfield	Trail	Torreon	Risdon	Onsan
Annualized Capital Cost	431.49	483.37	486.80	402.76	342.73
Corporate Charge	9.28	8.25	5.38	9.93	4.97
Net Operating Cost	334.38	344.35	265.30	385.38	445.27
Full Cost:	775.15	835.97	757.48	798.04	792.97

	Iijima	Asturiana	Juiz de Fora	Cajamarquilla
Annualized Capital Cost	480.51	478.80	566.55	600.71
Corporate Charge	6.96	7.27	9.25	8.36
Net Operating Cost	491.15	343.41	359.70	524.92
Full Cost:	978.62	829.48	935.50	1,133.99

II.5 Environmental Issues For Zinc Smelters And Mines

Until recently, the major environmental concern in zinc smelting was sulfur dioxide emissions into the air. Over the 1970s and 1980s most smelters dealt with this problem by increasing the capture of SO_2 from their roaster off gases and converting the SO_2 to sulfuric acid.

The Sherritt Gordon Pressure Leach (SGPL) process was adopted in some cases as an alternative to SO_2 capture and acid production. In SGPL the sulfur is recaptured as low purity elemental sulfur that is normally stored as a waste product, but which can be upgraded into a saleable product. This alternative has proven viable in situations where a smelter would receive a low net back price for its acid and the cost of producing acid would exceed the revenue. The Flin Flon, Manitoba, smelter is adopting this route to solving its SO_2 emissions problem rather than constructing a greenfield acid plant.

SGPL has also been adopted as a means of expanding capacity when environmental regulations prohibit any increase in SO_2 emissions that would result from adding new roaster capacity. This is the reason that the Datteln smelter in Germany has installed SGPL technology.

Thus, sulfur dioxide emission control is no longer a serious problem for the zinc smelting industry. Equipment and technology have been developed to deal with the problem and, in most cases, they have already been incorporated into smelter operations.

However, a new and potentially very serious environmental problem has emerged in the past few years. This concerns the safe handling of leach residues from secondary leach circuits.

Most smelters have incorporated secondary leaching to increase their zinc recoveries. The most widely used technology is the jarosite process. Some plants use the goethite and hematite processes. When the jarosite and goethite processes are employed, the resulting residue is an unusable material that must be disposed of or stored. Smelters that use the hematite process can sell the residue to cement manufacturers. The iron content of the hematite serves to bring iron-deficient cement up to specification. However, most smelters do not have the opportunity to sell hematite to cement manufacturers. It is only in certain regions that cement manufacturers need an iron addition to produce their product.

In years past, many smelters disposed of their jarosite and goethite residues by dumping them into the sea. A few smelters, e.g. Risdon, still follow this practice. In most countries, however, this practice has been banned because of the potential danger of water contamination. The residues contain such potentially harmful elements as cadmium.

Consequently, the common practice has been to store jarosite and goethite residues in containment ponds. Because of the high moisture content of the residues they can not simply be stored in waste piles.

The safety of this method of storage has now been called into question. There is evidence that jarosite, in particular, is much less stable than previously thought. This means that there is the possibility that some of the potentially dangerous metals contained in the residues could leach out and contaminate groundwater, rivers and streams.

Presumably, this potential problem could be dealt with by seeing to it that the containment ponds are lined with an impervious material. We suspect that in many countries this is how the problem will be dealt with. However, it is too soon to tell what kind of regulations will be adopted by the environmental authorities in the various countries. In most countries the issue is just now being examined.

One country that has already drawn up regulations is The Netherlands and these have caused a near panic throughout the industry. Since much of The Netherlands is below sea level, the concern over water pollution is probably more intense than in any other country.

The Dutch government has told Budelco -- a fifty/fifty joint venture of Shell/Billiton and Pasminco -- that by 1995 it will no longer be allowed to dispose of jarosite residues in containment ponds, regardless of how well lined these ponds may be. Furthermore, Budelco must clean up all of its existing jarosite ponds and has only until mid-1992 to present an acceptable course of action. Thus, even if Budelco chose to cease operations, it would not escape the cost of cleaning up the existing ponds.

Consequently, Budelco, and possibly other smelters in the future, face two problems. The first is how to deal with existing jarosite residue ponds. The second is whether and how to continue to operate using new residue treatment or disposal methods.

There are two possible routes to follow in dealing with existing residue ponds. The first is the cementation route. The residue would have to be dried, mixed with cement and stored on land. However, even in a cemented form the material could be considered potentially dangerous. That could necessitate storage in a toxic waste dump.

The second route would entail drying and pyrometallurgical treatment to separate the metals from an inert slag. Budelco has estimated the cost of building such a treatment facility at 300 Mn guilders (about $170 Mn).

For ongoing operations, one engineering company has estimated the cost of drying, calcining and storing jarosite residue could increase smelter operating costs by 7.5 cents/lb of zinc produced. This would not appear to be a viable long-term solution.

There are a series of other routes that could be taken. The simplest would be to abandon secondary leaching entirely. The primary leach residue, still rich in zinc, would be shipped to an ISF which would recover the zinc, lead, and precious metals. The drawback here is that the blended ISF feed has minimum concentration requirements for zinc and lead and a maximum for iron. Thus, there would be a limit to the amount of residues that the ISFs could blend into their feed.

It is worth noting that primary leach residues can also be treated at a lead smelter. Big River Zinc ships its residues to the Asarco lead smelter in Montana for treatment. Two drawbacks of this route are that the zinc content of the primary residue is lost and that the expense of shipping these residues any distance erodes the value of the recovered lead and precious metals. If a smelter can secure enough low-iron zinc concentrates, it can achieve an acceptable zinc recovery in the primary leach. This would make residue treatment at a lead smelter more viable.

A second approach would involve conversion from the jarosite to the hematite process. Hematite is said to be chemically stable, meaning it could be stored in waste piles. It is not certain that environmental authorities would accept hematite as a non-toxic substance that would not need special containment.

There is also less residue created using the hematite process. For a tonne of zinc concentrate grading 8 percent iron, the jarosite process produces 706 lbs of residue, the goethite process 441 lbs and the hematite process 287 lbs.

Thus, conversion from jarosite treatment to the more expensive hematite treatment in secondary leaching could provide the best short-term solution for smelters prevented from simple residue impoundment.

However, the general feeling throughout the industry is that residue storage is not the long-term solution. Since the iron content of zinc concentrate is the cause of the residue problem, the removal of iron would produce the solution.

One research target is to alter the technology employed at the concentrator. If a method could be found to separate out the iron at the milling stage, smelters could then treat iron-free concentrates and there would be no residues. Unfortunately, it would take a major metallurgical breakthrough to achieve this separation at the concentrator.

It seems more likely that the iron separation will have to be achieved at the smelter stage. There are a few processes being tested which hold considerable promise. A process being developed by Lurgi and Thyssen is called the Circulating Fluid Bed process. It was initially aimed at processing steel mill blast furnace flue dust. The process metallizes the iron into a useable product, while concentrating the zinc in the dust from 1 percent to 30 percent. The zinc would be further upgraded in a Waelz kiln so that it would be suitable as a smelter feed. Work is proceeding to adapt this technology to zinc smelter leach residues. One drawback is that the residues would have to be dried prior to treatment.

The Australian Sirosmelt process is also being tested on steel mill flue dust and zinc leach residues. It is claimed that this process can handle moist feed and can also take in a mixed feed of flue dust and leach residues. In this process oxygen is fed into the chamber at a very high temperature (4,000° F). The iron metallizes into a useable steel mill raw material. The slag launder is fed to a reducing furnace where the nonferrous metals are separated and recovered.

Horsehead Industries of the US is testing a process similar to Sirosmelt which it calls a Flame Reactor.

Lurgi is also experimenting with a new technology involving the solvent extraction of iron and the use of a QSL reactor to smelt the iron residues.

At this point it is impossible to state how this zinc residue problem will be resolved. We believe that it is likely that before long smelters such as Risdon will be prohibited from dumping residues in the sea. We also suspect that some countries will allow the continued storage of residues in impoundment ponds, but that these ponds will have to be securely lined to prevent any leakage into the groundwater.

For other smelters, such as Budel, it seems very likely that residue impoundment ponds will be prohibited, at least for jarosite residues. Impoundment of hematite residues could be an acceptable alternative, but this is by no means certain. If this is not an acceptable alternative, these smelters will face considerable costs in either neutralizing the residues or treating them to separate the contained metals.

Thus, the environmental burden of containing, neutralizing or processing leach residues will almost certainly be uneven across the industry. Some smelters will likely face a serious challenge to this continued economic viability while others will face a very modest increase in their operating costs.

We are not in a position at this time to estimate how each smelter's costs will be affected and, consequently, we have not incorporated this element into our future smelter cost calculations. We do feel it is safe to say, however, that smelters that will be allowed to continue to store jarosite residues in secure impoundment ponds will gain a cost competitive advantage over smelters that are forced to treat their residues. We suspect that smelters located in more remote regions --typically those near the mines -- will fare better than those located in highly populated industrial regions.

One additional environmental consideration that bears comment is the drive to reduce or even possibly eliminate the use of lead in commercial products. This would not directly affect zinc smelters, but it would affect most zinc miners.

At this point it is impossible to say how far the anti-lead pressure will extend. However, that pressure is intense and it is mounting. Lead has already been banned in most countries as a gasoline additive and as a component in most types of paint. In the US it is now banned in plumbing solders. There is some rationale for these prohibitions since they all deal with the danger of ingesting lead through air or drinking water.

However, there is little or no scientific support for the contention that lead in any product poses a threat since that product could ultimately end up in a municipal waste dump and the lead could subsequently leach into groundwater.

While we do not expect to see a prohibition of the use of lead in such vital products as auto batteries, it is not inconceivable that over the next decade or so an acceptable substitute to the lead acid battery could be developed. Once there is a viable alternative, the banning of lead batteries would be much more likely.

Should such events transpire, how would this affect the zinc and lead mining industry ?

First of all, it would drive up the price of zinc by a considerable margin. Mines would lose any revenue for lead since this would now be a waste product. All costs would have to be met from the revenue derived from zinc sales. (Presumably silver by-product revenues would also be lost since silver is recovered in the lead concentrate in most cases and the lead would not be processed.)

Second, mines in which lead is the sole or the dominant metal would close. This would include the Missouri mines in the US.

Third, mines deriving major by-product revenues from lead would see their costs escalate radically. For some the rise in the zinc price would be inadequate to compensate and closure would be necessary.

Fourth, bulk concentrates would probably no longer be commercially viable. Furthermore, ISF smelters and other smelters equipped to treat bulk concentrates would probably close. The cost of disposing of recovered lead as a hazardous material would probably render these plants uneconomical.

Fifth, mines producing zinc only or predominantly zinc would benefit greatly. They would see zinc prices increase while they would face little if any increase in cost. These mines would likely expand. Furthermore, some zinc-only orebodies that are presently uneconomical would be developed as a result of much higher zinc prices.

In summary, zinc mines highly dependent on their lead by-product would likely be forced to close. This lost zinc production would be replaced through the development of presently uneconomical zinc-only orebodies that would become viable through the significant increase in zinc prices.

III. ZINC SMELTER REVENUE

III.1 Introduction

Miners that sell zinc concentrates to custom smelters are paid for 85 percent of the contained zinc less a treatment charge per tonne of concentrate. The specified treatment charge is linked to a slab zinc reference price. When the actual market price is above the reference price the treatment charge increases according to a stated formula. When the actual market price is below the reference price the treatment charge decreases.

Custom concentrate terms for bulk concentrates provide for payment for both zinc and lead, as well as for gold and silver that are recovered in the lead bullion. As with zinc concentrates, payment is made for only a portion of the contained metal. In theory, these metal content deductions represent metallurgical losses in processing. For bulk concentrate contracts these payment reductions are stated as unit deductions. The unit deduction represents the difference between the percentage of metal contained in the concentrates and the percentage of metal paid for.

If a tonne of bulk concentrate grades 35 percent zinc it contains 771 lbs of zinc. A deduction of seven units means that payment is made for 28 percent or 617 lbs. Unit deductions are specified for zinc, lead, gold and silver.

Penalties are also imposed if the concentrate contains impurities above stated threshold levels. These impurities include iron, magnesia, mercury, silica, fluorine and arsenic.

The miner also must pay the freight cost to deliver the concentrates to the smelter. Thus, the calculation of the miners' revenues is fairly straightforward.

The calculation of the smelters' revenue is much more complex and varied. Smelter revenue sources include:

1. **the treatment charge**

2. **unpaid for zinc.** While payment is made for 85 percent of the contained zinc, more than that is recovered. The actual recovery varies from smelter to smelter based on process technology, equipment employed and operating efficiency. A 96 percent recovery is fairly typical, although the range is from about 92 percent to 98 percent.

3. **unpaid for lead.** While the miner is paid for the lead in bulk concentrates, the amount that is paid for is almost always less than the amount recovered. In some cases the lead content of zinc concentrates is also recovered.

4. **unpaid for by-product metals.** Gold and silver are paid for in bulk concentrates, but the amount recovered exceeds the amount paid for. In almost all cases, no payment is made to the miner for gold and silver or for other metals contained in zinc concentrates. These other metals include cadmium, germanium, bismuth, copper and indium -- the latter three are associated with the lead in bulk concentrates. These metals are not present in recoverable quantities in all concentrates and not all smelters are equipped to recover them. Thus,

concentrates with recoverable quantities of these by-product metals are sought out by smelters equipped to recover them.

5. **sulfur.** Almost all smelters capture most of the sulfur contained in concentrates. In most cases it is converted into sulfuric acid, although it may be recovered as elemental sulfur. The Japanese are the only smelters that also recover very dilute gas streams to produce gypsum. The value of the recovered sulfur varies widely from smelter to smelter based on the local market price and the delivery cost to reach the customer. Some smelters derive considerable revenue from their sulfur, while others derive very little.

6. **impurity penalties.** Properly equipped smelters can handle impurities in concentrates for less cost than the penalty charge imposed on the miner.

7. **zinc price premium.** The reference price used to pay the miner for the zinc in concentrates is the London Metal Exchange (LME). The price the smelter charges for slab zinc is usually at a premium above the LME. The amount of the premium varies from market to market based on competitive conditions and the presence or absence of tariff protection. In the worst case, smelters may have to sell some of their metal at the LME with no premium. This of course, would apply to metal sold for delivery into LME warehouses. At the other extreme, a smelter protected by a high tariff could sell its metal for 15 cents or more above the LME.

In any cost/revenue analysis it must first be determined how these various smelter revenue items are treated. In other words, it must be decided which are entered in the revenue column and which are applied as credits in the cost column.

We have devised an accounting methodology which is the normal industry practice. The revenue items include the treatment charge, unpaid for zinc and the slab zinc selling price premium over the concentrate buying price (the LME). This is the case for bulk concentrates, as well as zinc concentrates. For bulk concentrates the treatment charge per tonne of concentrate is assigned as zinc revenue. The amount of lead recovered above the amount paid for is assigned as a credit against the cost of producing zinc. Thus, unpaid for lead, unpaid for by-product metals and the value of recovered sulfur are assigned as credits against the cost of producing zinc.

The situation with impurity penalties is less clear cut. The penalty is imposed through an increase in the treatment charge. This would support its inclusion as a revenue item. However, the penalty is imposed to offset the added cost of processing and this would support its inclusion as a cost credit. In any case, this is not an item that is part of RSI's zinc smelter production cost model so we will not enter it in either column. We do not have adequate information on the cost of dealing with these impurities and, therefore, we have not included this element in our cost model. Thus, it would be incorrect to enter it as a revenue item. Some smelters may derive some net gain through impurity penalties, but this is not an important consideration in the overall cost/revenue balance.

While we do not include impurity penalties in our cost calculations, we will briefly comment on the items that draw penalties and any likely trends in the area.

Iron: The amount of iron in zinc concentrates determines the amount of leach residue that must be disposed of. For smelters facing a residue disposal problem this is becoming a very important consideration in concentrate sourcing. Smelters being supplied with low iron concentrates enjoy a cost savings in residue handling.

Most smelters currently set an allowable iron content limit in the range of 9 - 11 percent. The lowest known limit is 8 percent. It is widely expected that the maximum allowable limit for most smelters will move to 8 percent over the next few years.

Currently, smelters increase their treatment charge by $1.00 - 1.50 for every 1 percent of iron above the allowable limit. The trend seems to be towards increasing the penalty towards the $1.50 - 2.00 range.

There is presently no benefit for mines producing very low iron concentrates (below 3 percent) although this is a favored material. Many in the industry feel that over the next few years low iron concentrates could win treatment charges as much as 10 percent below terms paid for "normal" iron concentrates (3 - 8 percent). Smelters with the most serious residue disposal problems will offer the most attractive terms for low-iron concentrates.

Silica: A concentrate with a silica content above 4 - 5 percent can cause clogging in the filtration stage. Some smelters have installed equipment to deal with high-silica concentrates. Most smelters set the allowable silica limit at 4 percent, but some set the limit as low as 2 percent. The penalty increases the treatment charge by $1.50 - 2.00 for every 1 percent above the allowable limit.

Mercury: There is considerable variance among smelters on the allowable mercury limit. A high mercury content affects the quality of the sulfuric acid produced from the off gasses. Some smelters have installed mercury removal equipment and can handle concentrates running as high as 300-plus parts per million (ppm). These smelters impose a treatment charge penalty of only $2.00 - 3.00 on the high-mercury concentrates. Smelters not so equipped usually set an allowable limit in the 30 - 50 ppm range and impose a treatment charge penalty of $2.00 - 3.00 for every 100 ppm above that limit.

Fluorine: There is a wide range among smelters as to the allowable limit. The range is from 100 to 500 grams per tonne. Penalties run $1.00 - 2.00 for every 100 g/t above the limit.

Magnesia: Magnesia is important for smelters with jarosite residue disposal problems. The magnesia must be neutralized with lime and as a result the neutralized magnesia takes up 14 times the storage space of iron precipitate in the residue storage ponds. Normally, there is an inverse correlation between the iron and magnesia content. The allowable magnesia limit in concentrates for most smelters is 0.4 percent. The treatment charge penalty runs $1.50 - 2.00 for every 0.1 percent above the limit.

We will now turn our attention to the three elements that go into our calculation of smelter revenues -- the treatment charge, unpaid for zinc and the zinc metal selling price premium.

III.2 Treatment Charges and Unpaid For Zinc

Zinc treatment charges in 1991 are about $185/t of concentrates at a zinc metal reference price of $1,250/t. The treatment charge escalates by $1.25 for every $10 increase in the actual market price for zinc metal over the reference price. The treatment charge de-escalates by $1.25 for every $10 decrease in the actual market price below the reference price.

At a metal price of $1,117/t (50.7 c/lb), payable zinc at 85 percent of contained zinc, a metallurgical recovery of 96 percent of contained zinc, and a 55 percent zinc concentrate, the electrolytic smelter revenue per tonne of concentrate calculation would be as follows:

	$/TONNE CONCENTRATE
Treatment Charge Base	$185.00
De-Escalator ($1,250 - $1,117 = $133 /10 = 13.3 x 1.25)	- 16.63
Treatment Charge	$168.37
Zinc Contained (2205 x 0.55)	1,213 lb
Zinc Recovered (x 0.96)	1,164 lb
Zinc Paid For (x 0.85)	1,031 lb
Unpaid For Zinc (1164 - 1031)	133 lb
Value Of Free Zinc (50.7c x 133)	$67.43
Treatment Charge	$168.37
+ Unpaid For Zinc	67.43
Smelter Revenue	$235.80

The following example sets forth the calculation of revenue for an ISF smelter treating concentrates with an average grade of 44 percent zinc and 18 percent lead.

The treatment charge base is $215. This is adjusted for both zinc and lead prices. For zinc the reference price is

$1,250, the escalator is $2.00 for every $10 over the reference price and the de-escalator is $1.80 for every $10 below the reference price. For lead the reference price is $600 and the escalator is $1.55 for each $10 above the reference price. There is no de-escalator for lead.

The market prices for this exercise are $1,117/t (50.7 c/lb) for zinc and $551/t (25 c/lb) for lead. The unit deduction for zinc is seven and for lead is three. Metal recoveries are 94 percent for zinc and 95 percent for lead.

After calculating the value of free lead recovered by the ISF smelters, we will not assign it as smelter revenue but rather as a credit against zinc production costs.

	$ TONNE CONCENTRATE
Treatment Charge Base	**$215.00**
Zinc De-Escalator ($1,250 - $1,117 = $133 /10 = 13.3 x 1.80)	**- 23.94**
Lead De-Escalator (Not applicable)	**- 00.00**
Treatment Charge:	**$191.06**
Zinc Contained (2205 x 0.32)	**706 lb**
Zinc Recovered (x 0.94)	**664 lb**
Zinc Paid For (2205 x 0.25)	**551 lb**
Unpaid For Zinc (664 - 551)	**113 lb**
Value Of Free Zinc (50.7 c x 113)	**$57.29**
Lead Contained (2205 x 0.18)	**397 lb**
Lead Recovered (x 0.95)	**377 lb**
Lead Paid For (x 0.15)	**331 lb**
Unpaid For Lead (377 - 331)	**46 lb**
Value Of Free Lead (20c x 46) (25 c - 5 c refining charge)	**$9.20** (Assigned As Credit To Zinc Production Cost)
Treatment Charge	**$191.06**
+ Unpaid For Zinc	**57.29**
Smelter Revenue	**$248.35**

Thus, we see that in 1991 the combination of the treatment charge and unpaid for zinc in treating typical zinc and bulk concentrates would provide an electrolytic smelter a revenue of $235.80 and an ISF smelter a revenue of $239.73 per tonne of concentrate treated.

We will now project the revenues that these grades of concentrates would yield in 1995. It is a widely held belief throughout the zinc industry that treatment charges will increase at a faster rate than general inflation. There are both cost-push and demand-pull reasons for this belief. The cost pressures will come primarily from more stringent environmental controls. Some smelters will have to increase their sulfur capture to reduce sulfur dioxide emissions. However, this will not be the major cost problem on an industry-wide basis. Most smelters, especially those in the industrialized world, have already made the necessary investment in sulfur emission controls.

A potentially more serious problem involves the disposition of leach residues, especially jarosite residues. At the minimum, more securely lined containment ponds will have to be constructed. At the maximum, these residues will have to be treated in some way to make them benign. This could entail recycling through a pyrometallurgical facility or it could entail neutralization, solidification and storage in an enclosed storage unit. Chances are that some smelters will face much more stringent regulations and, hence, higher clean-up costs than others. In any case, virtually all smelters will face some increase in environmental costs.

The demand pressures will come from the need for new smelter capacity. The period of massive over-capacity is fast disappearing. To encourage the needed new investment, treatment charges will have to rise. This will begin to happen as we emerge from the current demand recession and smelter capacity utilization rates move up towards maximum achievable levels.

We project that by 1995 the base treatment charge for zinc concentrates will reach $240. The reference price should also rise as metal prices recover and our forecast reference price for 1995 is $1,600. We also believe that the price participation escalator will rise to $3.30 while the de-escalator will increase to $2.20. This would reflect the increased bargaining power of the smelters as capacity availability tightens.

For bulk concentrates, we project a 1995 treatment charge of $270. We assume the escalators and de-escalators will remain at current levels. The lead reference price would be $900.

The metal prices that we are forecasting for the 1995 average are $1,709/t (77.5 c/lb) for zinc and $908/t (41.2 c/lb) for lead.

The following examples calculate smelter revenues from the treatment charge and unpaid zinc in 1995. We assume percent payments and unit deductions will remain the same as at present.

ELECTROLYTIC SMELTER

	$/TONNE CONCENTRATE
Treatment Charge Base	$240.00
Escalator ($1709 - 1600 = 109 / 10 = 10.9 x 3.30)	+ 35.97
Treatment Charge	$275.97
Zinc Contained (2205 x .55)	1,213 lb
Zinc Recovered (x 0.96)	1,164 lb
Zinc Paid For (x 0.85)	1,031 lb
Unpaid For Zinc (1164 - 1031)	133
Value Of Free Zinc (77.5 c x 133)	$103.08
Treatment Charge	$275.97
+ Unpaid For Zinc	+103.08
Smelter Revenue	$379.05

ISF SMELTER

	$/TONNE CONCENTRATE
Treatment Charge Base	$270.00
Zinc Escalator ($1709 - $1600 = 109 / 10 = 10.9 x 2.00)	+ 21.80
Lead Escalator ($908 - 900 = 8 / 10 = 0.8 x 1.55)	+ 1.24
Treatment Charge	$293.04
Zinc Contained (2205 x 0.32)	706 lb
Zinc Recovered (x 0.94)	664 lb
Zinc Paid For (2205 x 0.25)	551 lb
Unpaid For Zinc (664 - 551)	113 lb
Value Of Free Zinc (77.5 c x 113)	$87.58
Lead Contained (2205 x 0.18)	397 lb
Lead Recovered (x 0.95)	377 lb
Lead Paid For (x 0.15)	331 lb
Unpaid For Lead (377 - 331)	46 lb
Value Of Free Lead (36.2 c x 46) (41.2 c - 5 c refining charge)	$16.65 (Assigned as credit to zinc production cost)
Treatment Charge	$293.04
+ Value Of Unpaid For Zinc	87.58
Smelter Revenue	$380.62

In most cases, ISF smelters consume both bulk concentrates and zinc concentrates to yield an optimal zinc:lead production rate. However, in Australia the Cockle Creek smelter typically consumes low grade zinc concentrates and bulk concentrates yielding a much lower zinc:lead ratio. The total zinc and lead metal contained in the concentrate feed is less than 50 percent whereas European ISF smelters have combined lead and zinc contained metal content of 55-60 percent.

As a consequence, the ISF smelter revenue calculation must take into account the amount of bulk and zinc concentrates and tabulate separately the respective revenues. As it happens, the difference in revenue between the zinc and bulk concentrates is less than $1/tonne concentrate. The following table contains the overall smelter revenue for ISF plants.

1995 ISF OVERALL SMELTER REVENUE

	Zinc Conc.	Bulk Conc.	Overall Conc. Blend
Concentrate Grade (%)	55	32	43.5
% of Total Feed	50	50	100
Smelter Revenue	379.05	380.62	379.84

The smelter revenue numbers developed above are per tonne of concentrate treated. Since our smelter production cost numbers are per tonne of zinc metal produced, we must convert the revenues per tonne of concentrate to revenues per tonne of metal. This is done by dividing the concentrate revenues by the amount of recoverable zinc contained (the concentrate grade and the recovery percentage). The revenues from the treatment charge and unpaid for zinc on the basis of a tonne of zinc metal produced are as follows:

	1991	1995
Electrolytic Smelter	$446.59	$717.90
ISF Smelter	$607.36	$928.93

A final note in dealing with treatment charges concerns the location of the smelter and its concentrate suppliers. The 1991 terms we set out above are typical for custom smelters in Europe and the Far East taking imported concentrates.

In most cases, smelters in concentrate exporting regions can impose higher treatment charges. The reason for this is that the mine pays the cost of transporting the concentrate to the smelter. Therefore, the mine must consider the treatment charge and the transport cost when evaluating the terms offered by competing smelters. The smelter that is closer to the mine (i.e., with a lower concentrate delivery cost), can impose a higher treatment charge and still leave the mine with a higher net revenue.

This may best be explained through an example. **Region A** has mine production of 200,000 tonnes of zinc in concentrate.

There is a 100,000 tpy smelter in **Region A** that takes half the mine production. The other 100,000 tonnes of zinc in concentrate must be shipped across the ocean to smelters in **Region B**.

The concentrate freight cost for a mine in **Region A** to the smelter in **Region A** is $5/t, while to ship to the smelter in **Region B** costs $30/t. The smelter in **Region B** is offering treatment charges of $200/t. The combined cost to the mine in **Region A**, therefore, would be $230/t. The smelter in **Region A** could then offer a treatment charge of $224/t. This would produce a total cost for the mine of $229/t and it would be better off by $1/t selling to the local smelter.

The smelter in **Region A** can secure a treatment charge $24/t higher than the smelter in **Region B** and still provide the mine with a slightly higher net revenue. In actual industry practice the smelter in **Region A** could impose an even higher treatment charge so that the combination of the treatment charge and freight cost would exceed the combination involved in selling to the smelter in **Region B**. This is because payment to the mine is based on the time when the concentrates are delivered to the smelters. The extra time involved in delivering to the smelter in **Region A** means the mine loses the interest earning potential of its revenues while the shipment is in transit.

The commercial principle that this example illustrates is that in the custom concentrate business the proximity of a mine to a smelter translates into an advantage for the smelter, not for the mine.

III.3 Zinc Price Premium

Zinc smelters use the LME zinc quotation as the payment price on their concentrate buying contracts. Their selling price for slab zinc is normally at a premium over the LME price. This premium represents another source of smelter revenue.

The amount of the premium smelters receive varies over time based on market conditions and from country-to-country based on import tariffs and competitive conditions.

In late-1991, with the market in surplus and prices badly depressed, producer premiums have also been forced down to very low levels. However, we are concerned here with projecting smelter revenues in 1995 and our forecast is for a much stronger zinc market at that time. Thus, our projections of producer premia in 1995 assume historically normal levels.

An explanation of producer premia must be conducted on a country or regional basis.

Europe:

There is a 3.5 percent ad valorem duty for the Common Market. This translates to 1.75 c/lb at 50 cent zinc, 2.10 cents at 60 cents and 2.45 cents at 70 cents.

However, European smelters do not get much benefit from this tariff. It only covers zinc produced outside of the EEC and European smelters produce more zinc than Europe consumes. Thus, there is strong competitive pressure among European smelters for sales within Europe. Under normal conditions, most European smelters derive a better net back price for sales made within their local markets than they do on exports.

We believe that a normal weighted average premium received by European smelters is about 1.5 c/lb or $33.08/t and we will use this for our 1995 revenue calculation.

North America:

The U.S. duty on slab zinc is 1.5 percent ad valorem. This equals 0.75 cents at 50 cent zinc, 0.9 cents at 60 cents and 1.05 cents at 70 cents. Canada does not have an import duty on zinc. The U.S. duty for Canadian zinc is being phased out and it seems quite possible that Mexico may also gain duty-free access to the United States market.

The United States imports metal from Europe and the price of that metal effectively sets the maximum price that North American producers can charge under normal market conditions.

European smelters always have the option of selling zinc into the LME. Thus, the LME is the minimum price that they can always receive. The price they will accept for sales to the United States must be better than the LME, plus the U.S. duty, plus the added freight cost to reach United States customers. If the United States price premium over the LME falls below 5 cents, most European smelters do better selling into the LME. In a reasonably strong market a U.S. premium of about 6 cents is normal. That is the premium we will use in the 1995 revenue calculations.

Japan:

The Japanese impose a flat duty of 8 yen/kg rather than an ad valorem duty. The U.S. dollar value of that duty fluctuates with the dollar/yen exchange rate. At 135 yen to $1.00, it is worth 2.68 cents. At 120 yen to $1.00, it is worth 3.02 cents. Thus, tariff protection increases as the Japanese competitive position weakens.

The Japanese smelters quote a domestic price called the Japanese Producer Price (JPP). The JPP premium over the LME cash quote usually runs about 13 - 15 cents. However, the JPP is normally discounted, especially on sales to major consumers. The average realized premium over the LME is usually about 7 c/lb and we will use that in our 1995 revenue calculations.

Because of the high freight cost to ship LME metal to the Far East, producers usually get premia of about 5 cents over the LME when selling into duty free countries, e.g. Taiwan. Thus, the 7 cent Japanese premium is simply the normal Far East premium plus the Japanese import duty.

Korea:

Korea is in the process of reducing its duty from 10 percent ad valorem to 5 percent. Unless the phase down is delayed, which is possible due to the state of the market, by 1995 the Korean duty would be worth 2.5 cents at 50 cents, 3.0 cents at 60 cents and 3.5 cents at 70 cents. Because of the normal Far East premium of 5 cents over the LME, the Korean smelter could realize a domestic selling price in 1995 of about 8 - 9 cents over the LME.

Thailand:

The Thai smelter is highly protected with a 20 percent ad valorem tariff. The value of the tariff ranges from 10 cents at 50 cents to 14 cents at 70 cents. When the normal Far East LME premium of 5 cents is added in, the domestic zinc price in Thailand can run 15 - 20 cents over the LME.

Brazil:

The situation in Brazil is somewhat unsettled. The zinc tariff was reduced from 10 percent ad valorem to 5 percent, but it is possible that this could be adjusted. Brazilian producers pay a 5 percent value tax on their domestic sales, so that a 5 percent import duty merely keeps domestic producers even with importers.

Australia:

The import duty is 2 percent ad valorem. This equates to a value of 1 cent at a zinc price of 50 cents, 1.2 cents at 60 cents and 1.4 cents at 70 cents. Because of the normal Far East premium of 5 cents over the LME, the domestic Australian zinc price is normally about 6 - 7 cents above the LME.

It is important to note that tariff protection adds no value to the zinc that protected smelters have to export. This is a major consideration for such planned projects as the Thai smelter. The Paedang smelter at Tak currently produces about 72,000 tpy. The planned ISF would produce 60,000 tpy of zinc by

1995. If the domestic market grows to only 100,000 tonnes by 1995, some 30,000 tonnes of the new plant's output would have to be exported. Thus, the new smelter could receive a revenue of about 95 c/lb for half of its production (77.5 cent LME plus 17.5 cent home market premium) and 82.5 cents for the other half (77.5 cent LME plus 5 cent Far East premium).

III.4 Smelter Revenue Projections for 1995

We will present our projections of smelter revenues for 1995 for the eight greenfield projects and the nine incremental expansions. The "base" revenue will be the same in each case -- $717.90 for electrolytic smelters and $928.93 for the ISFs. This is made up of the treatment charge prevailing in the main custom smelting regions, i.e. Europe and Japan, and the value of unpaid for zinc. Smelters enjoying a locational advantage for their concentrate purchases are assigned a treatment charge (TC) premium. Each will then be assigned a metal price premium representing the difference between that smelter's average selling price and its concentrate buying price (LME).

The treatment charge premium, i.e. the dollar value of a smelter's locational advantage, is based on the delivery cost differential a mine would face in selling to a local smelter versus an overseas smelter. Smelters that have access to local concentrates and that are located long distances from competing European and Japanese smelters enjoy the highest treatment charge premia. Smelters in Europe and Japan, which import concentrates, do not derive any premia. Other Far Eastern smelters, e.g. those in Thailand and Indonesia, would be competing with Japanese smelters for foreign concentrates and would have no locational advantage.

Of the 17 smelters under consideration, no treatment charge premium is assigned to those in Japan, Korea, Thailand, Indonesia, France and Spain.

The largest treatment charge premium would go to Cajamarquilla in Peru because of the high cost of shipping Peruvian concentrate to Europe and Japan. We calculate the premium at $73. Australian smelters would gain premia in the range of $38-48. Smelters in Eastern Canada would gain from the higher cost of shipping concentrates to Europe. This would be worth about $28. We calculate the Mexican premium at $49.

The Trail smelter in British Columbia would presumably base an expansion on concentrates from Red Dog in Alaska. Thus, it would only benefit by the incremental freight cost advantage in shipping from Alaska to Trail as against Japan and Europe. We set that value at about $15. The Brazilian smelter would also gain only an incremental freight advantage for imported Peruvian concentrates. The freight advantage for Peruvian miners shipping to Brazil as against Europe and Japan would be about $27.

The metal selling price premium ranges from 12 cents in Thailand to 1.5 cents in Europe. For the Thai smelter we assume that half of its production would be sold domestically at a 19 cent premium and half to other Asian consumers at a 5 cent premium. As we noted earlier, zinc prices in the Far East run about 5 cents over the LME before any import tariffs are applied.

We have assigned a 6 cent premium to the North American smelters, based on the US tariff and freight cost from competing European smelters. The combination of the Far East premium plus import tariffs gives the Japanese a 7 cent premium and the Koreans an 8.5 cent premium.

Australian production is assumed to be sold to other Australasian countries for a 5 cent premium. For Indonesia we assume a 5 percent ad valorem tariff would be imposed to aid a new smelter. However, we also assume that a third of production would have to be exported at the Far East premium of 5 cents. The weighted average premium would be 7.3 cents.

The Brazilian smelter enjoys a 5 percent ad valorem tariff that should support a home market premium of about 7 cents. The Peruvian smelter is assumed to export all of its production. Net of duty, it could sell in the US at about 5 cents over the LME.

The following table displays the calculation of revenues for the 17 smelter projects in 1995 dollars/tonne of metal.

1995 SMELTER REVENUE

($/tonne)

	Base TC + unpaid zinc	TC premium	Metal premium	Total revenue
Greenfield projects				
New Brunswick Elec.	$717.90	$27.90	$132.30	$878.10
New Brunswick ISF	928.93	27.90	132.30	1,089.13
Japan Elec.	717.90		154.35	872.25
Japan ISF	928.93		154.35	1,083.28
Thailand ISF	928.93		264.60 (1)	1,193.53
Queensland Elec.	717.90	37.74	110.25	865.89
Indonesia Elec.	717.90		161.70 (2)	879.60
France Elec.	717.90		33.08	750.98
Incremental Expansions				
Valleyfield	717.90	27.90	132.30	878.10
Trail	717.90	15.17	132.30	865.37
Torreon	717.90	48.82	132.30	899.02
Risdon	717.90	42.59	110.25	870.74
Onsan	717.90		187.43	905.33
Iijima	717.90		154.35	872.25
Asturiana	717.90		33.08	750.98
Juiz de Fora	717.90	27.26	154.25	899.51
Cajamarquilla	717.90	72.86	110.25	901.01

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(1) assumes half of production sold domestically at 19 cent premium and half exported to Asian countries at 5 cent premium.

(2) assumes 5 percent AV duty. Two-thirds of production sold domestically at 8.5 cent premium and one-third exported to Asian countries at 5 cent premium.

IV. SMELTER COST and REVENUE COMPARISONS

We will now draw together the 1995 full cost projections from Chapter III and the revenue projections from Chapter IV to assess the potential profitability of the 17 projects.

The table on page IV-6 presents the balance of full costs and total revenues. The point should again be emphasized that our full cost number for each project includes a 20 percent target rate of return on the equity investment. Thus, in the third column of the table we use the term "net balance" rather than "profit or loss". A smelter with a zero balance would be able to achieve its target rate of return.

Of the greenfield projects, the three ISF smelters fare best primarily because of the revenue contribution of unpaid for lead, gold and silver. The Japanese ISF is the only greenfield project to exceed a 20 percent target rate of return. The New Brunswick ISF comes very close to meeting this target. It is the only one of the three ISFs that would receive a treatment charge locational premium. The Thai ISF also comes close to meeting the target. We have assumed that half of this smelter's metal would have to be exported. Those sales would not receive the benefit of the very high 20 percent ad valorem import duty. The Thai plant is still assigned far-and-away the highest average metal price premium of $265. Were all of the smelter's 60,000 tonnes of production sold domestically, the metal price premium could reach $419. That would be enough to increase total revenue to $1,307 and the net balance would shift from -$57 to +$56. It should be noted that Thai zinc consumption is expanding rapidly and that total domestic production could probably be absorbed internally before 2000.

None of the greenfield electrolytic smelters would achieve the target rate of return. The Indonesian project would come closest, falling short by $145. As with the Thai ISF, we have assumed that a portion of this smelter's output would have to be exported in 1995. We also assumed that Indonesia would impose a 5 percent ad valorem duty to support the smelter. At present there is no import duty in Indonesia since there is no domestic smelting industry to protect. Should the government be willing to enact a 10 percent ad valorem tariff and should domestic demand increase sufficiently by 1995 to absorb 160,000 tpy of zinc, the smelter could receive a metal price premium of $281 (10% x 77.5 c + 5 cents Far East premium = 12.75 c). This would yield a total revenue just $25/tonne below full cost. This would mean that the smelter would be profitable but the rate of return on the equity investment would fall a bit below 20 percent.

None of the other greenfield electrolytic smelters would seem to have a chance of economic viability.

Thus, it is not surprising that the only greenfield smelter projects currently receiving serious consideration are the Japanese and the Thai ISFs and the Indonesian electrolytic smelter. The Thai project has already been announced, while Nippon is reportedly committed to going ahead with the ISF project. The Indonesian smelter is being evaluated as a potential outlet for concentrates from CRA's huge Century mine project in Queensland. CRA believes that a smelter in a rapidly growing East Asian country would make more economic sense than a new smelter in Queensland. Our analysis supports this view.

Turning to potential incremental expansions, our analysis shows that five of the nine projects could achieve the target rate of return. The most profitable would be Torreon, Valleyfield and Risdon.

Torreon is currently undergoing an expansion that will bring it from 100,000 tpy to 180,000 tpy by 1994. Consequently, a further 100,000 tpy expansion to 280,000 tpy is not even being considered at this time. Noranda has been looking at an expansion of Valleyfield off-and-on for a few years. The currently depressed state of the zinc market has indefinitely deferred any further consideration. However, we suspect that should the market recover as we forecast, this potential expansion will again be evaluated. The major advantages to such a project include low cost electricity, local concentrates and duty-free access to the US market. These would give a Valleyfield expansion a decided advantage over a European expansion aimed at the US market.

Pasminco has also been studying a Risdon expansion off-and-on for some time. However, Pasminco's financial position is presently quite weak because of the depressed zinc and lead markets. Furthermore, some of its existing mines are high cost and could face closure. An expansion of Risdon could be conditional on new mine development. The Dugald River deposit in Queensland is currently under evaluation. However, concentrate shipping costs from Queensland to Tasmania would be very high because of the protection the Australian government extends to domestic shipping companies. This protection is afforded to support the relatively high wages of Australian seamen and dock workers.

Pasminco also faces a potentially serious problem with its existing operations at Risdon. Currently, jarosite residues are dumped into the ocean. There is mounting environmental opposition to this practice and should it be prohibited at some time in the future, Pasminco would face a serious financial problem in developing an acceptable alternative for its residue disposal.

The other two incremental expansions that would appear viable are Onsan in Korea and Trail in British Columbia. Onsan is currently undergoing an expansion to 200,000 tpy by 1993. Korean consumption has been expanding rapidly and Korea will probably soon become a net importer, despite the Onsan expansion. Korea is often mentioned as a potential site for new zinc smelter capacity, primarily because of its strong consumption growth. Political developments could play an important role in determining zinc smelter investment decisions. Should North and South Korea reunify, the South would immediately gain access to the 50,000 tpy of slab zinc that the North currently exports --primarily to Japan. Longer term, a reunified Korea would almost certainly produce a strong surge in zinc consumption, as the industrial infrastructure of the North would be rebuilt and expanded.

A few years ago Cominco seriously considered expanding Trail. The expansion probably would have gone forward were it not for an unresolved conflict with the British Columbian government over the water tax related to hydroelectric power generation. At the moment, Cominco is not considering a further zinc smelter expansion. It has other important capital spending projects, foremost is its new QSL lead plant that has not been able to operate properly and is currently off-stream. Within a few years, however, we suspect that Cominco will reconsider a Trail expansion. Assuming a favorable resolution of the water tax issue, such an expansion would gain the benefit of low cost electricity and duty-free access to the US market. Concentrate supply could be a problem, however. The Sullivan mine will close at the end of the decade. Red Dog's concentrate capacity is presently only slightly more than Trail's capacity. Thus, a Trail expansion would have to be based on a Red Dog expansion or other Western Canadian concentrates.

The four incremental expansions that do not meet the target rate of return in our analysis are Asturiana in Spain, Iijima in Japan, Juiz de Fora in Brazil and Cajamarquilla in Peru.

It is very difficult to assess the Brazilian and Peruvian projects because of the unsettled economic conditions in those countries. Both projects suffer in our analysis from a high capital relative cost. Should conditions improve significantly over the next few years and the currency inflation/exchange rate situation stabilize at a competitive level, both of these projects would look much better.

The Japanese and Spanish projects also suffer from a high relative capital cost, but we see no reason to assume that this is likely to change. In any case, Asturiana is just completing an expansion from 220,000 tpy to 320,000 tpy and no further expansion is currently under consideration. The Iijima expansion that is being considered would probably be as replacement for older and higher cost capacity that would be decommissioned.

The following table compares the projected full costs with revenues for the eight greenfield projects and the nine incremental expansions. For the nine expansions we assume that the only capital repayment in 1995 would be for the incremental expansion. Figures are in 1995 dollars/tonne of metal.

Greenfield Smelters	Full Cost	Total Revenue	Net Balance
New Brunswick Electrolytic	$1,130	$878.10	(251.90)
New Brunswick ISF	1,113	1,089.13	(23.87)
Japan Electrolytic	1,419	872.25	(546.25)
Japan ISF	922	1,083.28	161.28
Thailand ISF	1,251	1,193.53	(57.47)
Queensland Electrolytic	1,060	865.89	(194.11)
Indonesia Electrolytic	1,025	879.60	(145.40)
France Electrolytic	1,108	750.98	(357.02)
Incremental Expansions			
Valleyfield	$775.15	$878.10	$102.95
Trail	835.97	865.37	29.40
Torreon	757.48	899.02	141.54
Risdon	798.04	870.74	72.70
Onsan	792.97	905.33	112.36
Iijima	951.89	872.25	(79.64)
Asturiana	829.48	750.98	(78.50)
Juiz de Fora	935.50	899.51	(35.99)
Cajamarquilla	1,133.99	901.01	(232.98)

V. TECHNICAL and ECONOMIC CONSIDERATIONS FOR A NEW BRUNSWICK SMELTER

V.1 Introduction

In this chapter we will examine two alternative zinc smelting technologies to determine whether or not they could appreciably improve the economic viability of a greenfield New Brunswick smelter.

The two processes are the Sherritt Gordon Pressure Leach (SGPL) and the Ferric Chloride Leach (FCL). We will briefly describe the processes and then present our capital cost, operating cost and full cost calculations. We will then compare full costs with revenue projections for each process.

We will examine the investment tax incentives available for a new smelter in New Brunswick. We will estimate how these incentives could affect the economic viability of a new smelter.

A final section will draw together the conclusions of our analysis.

V.2 Alternative Smelter Technologies

V.2.1 Sherritt Gordon Pressure Leach

The Sherritt Zinc Pressure Leach Process directly leaches zinc bearing concentrates to produce a solution which can be treated by conventional purification and electrowinning processes for the recovery of zinc metal. In addition, the process produces a leach residue which can be treated to recover elemental sulfur and other by-product metals.

In essence, the Sherritt Gordon Pressure Leach Process replaces the roasters, sulfuric acid plant, calcine-ferrite leach and jarosite precipitation sections of a conventional electrolytic smelter with pressure leach autoclaves and a sulfur-plumbo-jarosite flotation section.

A key feature of the pressure leach process is that the sulfide content of the zinc or bulk concentrates is converted to elemental sulfur rather than sulfur dioxide, eliminating sulfur emissions into the atmosphere.

In 1978, a study was conducted to analyze the application of the Sherritt Gordon Pressure Leach system to New Brunswick zinc and bulk concentrates. Capital and operating costs were estimated for a 100,000 tpy plant using a single-stage and two-stage leaching circuit.

In the single-stage leach, the iron and sulfuric acid levels in the solution are high enough that a two-stage iron removal, system is needed. In addition, only about half of the copper can be successfully extracted in a single-stage leach. The two-stage leach has more efficient utilization of acid and, thus, the solution is low in both iron and sulfuric acid. A single-stage iron removal system is required for treating two-stage leach. Much higher copper recovery is achievable with a two-stage leach; the recovery rate would be about 75 percent versus about 50 percent in a single-stage leach.

The estimated capital costs for a two-stage leach system would be $111.2 Mn in 1977 Canadian dollars. The capital costs for the purification and electrowinning tankhouse would be the same as for an electrolytic smelter. Operating costs for a two-stage leach system would be $21.65 Mn in 1977 Canadian dollars.

In 1982, a modified two-stage leach system was analyzed for recovery of a high grade lead-silver concentrate from leaching New Brunswick bulk lead-zinc concentrates. The capital costs included the provision for a residue upgrading section which would result in the recovery of 99 percent of the lead and 70 percent of the silver contained in the concentrate. In addition, the recovery rates of zinc and copper would increase to 96 and 89 percent from 95 and 75 percent, respectively.

The estimated capital cost is $198 Mn in 1982 Canadian dollars while the operating costs would be $42 Mn. However, it is instructive to point out that the cost estimates included the residue treatment plant for achieving higher recovery rates for lead and silver using New Brunswick bulk concentrates.

Following a discussion with the Sherritt Gordon engineers, it has been determined that the SG process would achieve the most successful results with a combination of zinc concentrates and bulk concentrates. There has been no research development since 1982 on reducing the capital and operating costs for a residue treatment plant which would be needed if the plant uses only bulk concentrates.

The general consensus is that the two-stage leach process using about two-thirds zinc concentrates and one-third bulk concentrates would be the most appropriate feed mix.

There have been several applications of the SG process in zinc smelting, including Trail and Kidd Creek in Canada and Datteln in Germany. By 1994, Hudson Bay Mining will be using the SG process to treat all of its zinc concentrates; the other plants have dedicated only a portion of their total concentrate feed to the SG process. Thus, there is no existing smelter cost data with which to base our greenfield New Brunswick zinc smelter using the SG process. As a consequence, we have estimated costs based on public documents and the original study prepared in 1977 for the two-stage leach process.

An integral part of the Sherritt Gordon process is to produce elemental sulfur with an acceptable quality for the international fertilizer market. Impurities such as mercury and arsenic have been a concern to the fertilizer industry but are no longer a serious problem with the SGPL process. However, there may be a problem with selenium but even in these circumstances, elemental sulfur can still be sold albeit with penalties.

At this juncture, it is undetermined whether the New Brunswick concentrates would produce a lower quality product without extensive metallurgical testing. Therefore, we have estimated the potential by-product revenue accrued from the sale of elemental sulfur.

We have developed cost estimates for a 100,000 tpy SG smelter in New Brunswick. First, we have taken our base case 160,000 tpy electrolytic smelter with a 1985 US base cost of $2,713/tonne and recalibrated for a 1990 100,000 tpy smelter in New Brunswick. This calculation is as follows:

CAPITAL COST ESTIMATE
($/tonne metal)

	1985	1995
U.S. Base	2713	
Scale Factor (1.18)	3201	
Capital Relative Cost Index	0.96	1.20
Adjusted Cost Base	3073	3841
Cost Inflation (13.84%)		4373

Next, we adjusted the 1990 cost per tonne of a standard electrolytic smelter of $4,373 to incorporate the SG pressure leach (SGPL) technology. With the SG process there is no roaster, acid plant or atmospheric leach and iron removal plant. We estimate that these facilities constitute 37 percent of the cost of a standard greenfield electrolytic smelter.

The rest of the plant would have the same costs with either technology. Thus, we can take 63 percent of the cost of a standard electrolytic smelter, or $2,755/tonne, as the base to which we must add the equipment used in the SGPL system in order to calculate total costs at the operation.

Sherritt Gordon estimates that the capital cost in 1990 dollars for a plant producing 100,000 tpy of zinc was $77.8 Mn or

$778/tonne. By adding this to $2,755, we reach a cost per tonne for the entire plant of $3,533. This is $840 less than the cost per tonne of a standard electrolytic smelter.

We can now bring this to a 1995 base as follows:

	1990	1995
Capital Relative Cost Index	1.20	1.19
Cost Base	3533	
Adjusted Cost Base		3504
Cost Inflation (19.67%)		4193
Capital Cost/Tonne	3522	4193

Annualized at LIBOR plus 3 percent (11.5 percent), the capital cost, which incorporates a 20 percent return on the equity investment, works out to $599.

We have developed operating costs for the 100,000 tpy SGPL plant based on Sherritt Gordon's estimates of percentage differences with a similar size standard electrolytic smelter. The comparison would be as follows:

OPERATING COST COMPARISON

($/tonne metal)

	Electrolytic	SGPL
Labor	182.80	149.90
Fuel	13.16	15.00
Electricity	140.66	162.35
Supplies/Equipment	191.30	180.17
Sulfur Credit	-36.63	-46.50
By-Product Metal Credit	-0.15	-34.96
Transport To Market	59.35	59.35
Working Capital	1.53	1.53
Net Operating Cost	552.02	486.84

The labor cost per tonne is lower with SGPL since there is a savings from not having to blend concentrates and in the roaster maintenance. The electricity input per tonne is somewhat higher. The electricity savings from not operating an acid plant are more than offset by the electricity consumption in the oxygen plant and in the autoclave. The SGPL plant would have a slightly lower cost input for supplies and equipment.

The SGPL plant is not assigned a sulfur credit. The elemental sulfur produced is of non-commercial quality. An additional investment would be needed to upgrade the sulfur to a saleable product. In the absence of a high price local sulfur market, this investment would probably not be justified.

The SGPL plant would gain a much better by-product metal credit through unpaid for lead and silver. This would just about equal the sulfur credit that a standard New Brunswick electrolytic smelter would expect.

Thus, the projected 1995 net operating cost for a 100,000 tpy SGPL smelter would be $66/tonne less than for a similar size conventional electrolytic smelter.

The buildup of the full cost of the SGPL smelter, including the 20 percent return on the equity investment, would be as follows:

Annualized Capital Cost	**$599**
Corporate Charge	**19**
Net Operating Cost	**487**
Full Cost:	**$1,105**

1995 SHERRITT GORDON PROCESS
OVERALL SMELTER REVENUE

	Zinc Conc.	Bulk Conc.	Overall Conc.
Concentrate Grade (%)	55	34	46.6
% of Total Feed	60	40	100
Smelter Revenue	379.05	380.62	379.68

The assumed revenue per tonne of concentrate would be about the same as we calculated earlier for a New Brunswick ISF.

However, when the smelter revenue per tonne of concentrate is converted into metal, the Sherritt Gordon process revenue is lower since it has a higher zinc content in the concentrate (46.6 versus 43.5) and a higher metallurgical recovery rate (95 versus 94 percent). The following tables set forth the smelter net profit.

Base TC + Unpaid Zinc	**$857.65**
TC Premium	**27.90**
Metal Premium (6 c/lb)	**132.30**
Total Revenue:	**$1017.85**

The cost/revenue comparison would be as follows:

Total Revenue	**$1,018**
Full Cost	**-1,105**
Net Balance:	**-87**

Thus, our calculations indicate that this smelter would not meet the target rate of return on equity investment, although it would come much closer than the 160,000 tpy New Brunswick electrolytic smelter costed earlier in this report. That facility would fall $252/tonne below target.

V.2.2 Ferric Chloride Leach

The fundamental constraint to improving the economic viability of the New Brunswick mining and smelting operations is the relatively lower metallurgical recoveries from ore to zinc, lead, copper and bulk concentrates. Research undertaken by Canmet indicates that overall metallurgical recoveries would increase substantially if the operation produced only a bulk concentrate containing zinc, lead, copper and silver rather than three selective concentrates for the base metals. Typically, the silver is recovered in either the lead or copper concentrate through selective milling technology.

The bulk concentrate could not be treated through conventional smelting technology such as the electrolytic or ISF process. The ISF smelters typically treat a combination of bulk and zinc concentrates in order to meet specific concentrate feed requirements.

An ISF usually requires a minimum combined zinc and lead concentrate grade of 45 percent; many plants are using combined zinc and lead grades of 55-60 percent. Moreover, there are strict limitations on the amount of copper that can be contained in the bulk concentrate.

According to Canmet, a bulk concentrate with combined zinc and lead grades totalling 40 percent would be the most amenable to achieving maximum metallurgical recovery rates for all metals.

The following table contains the assumptions for New Brunswick concentrates under the conventional selective concentrate process and the FCL process.

METALLIC FLOWSHEET COMPARISON
NEW BRUNSWICK

	FCL Process	Conventional Process			
	Bulk Conc.	Zn Conc.	Pb Conc.	Cu Conc.	ISP
Concentrate Grade					
Zn (%)	**30.0**	**50.0**	**4.5**	**3.0**	**33.0**
Pb (%)	**10.4**	**2.0**	**34.0**	**7.0**	**18.0**
Cu (%)	**1.0**	**0.3**	**0.6**	**23.0**	**0.7**
Ag (g/t)	**278.0**	**90.0**	**495.0**	**2950.0**	**350.0**
Flotation Recovery (ore to conc.)					
Zn (%)	**96.0**	**72.0**	**3.0**	**0.3**	**8.0**
Pb (%)	**82.0**	**7.0**	**50.0**	**2.0**	**11.0**
Cu (%)	**78.0**	**10.0**	**9.0**	**58.0**	**4.0**
Ag (%)	**75.0**	**11.0**	**25.0**	**25.0**	**7.0**
Process Plant Recoveries (physical only)					
Zn (%)	**96**	**95**	**--**	**--**	**95**
Pb (%)	**96**	**--**	**95**	**--**	**95**
Cu (%)	**95**	**--**	**--**	**95**	**--**
Ag (%)	**95**	**--**	**97**	**97**	**97**

The FCL process produces refined zinc and lead as well as a high grade copper/silver cement cake which is equivalent to blister copper. Cadmium could also be recovered but this would depend on the magnesium content of the concentrate.

Since no sulfur dioxide is generated in the FCL process, elemental sulfur is produced but it is of below market quality. Thus, it is assumed that the smelter would not receive a sulfur credit unless the product were upgraded sufficiently. This would entail additional cost.

The process also produces iron-bearing residues, primarily goethite, which would be disposed of in tailing ponds. Goethite is considered relatively stable waste material. Under current environmental regulations these residues could be impounded and would not have to undergo further treatment.

The more serious environmental problem could be the chloride disposal. Lime is added in the leaching and oxyhydrolysis sections of the plant to adjust the pH. The overflow of liquid waste stream contains about 120 gallons per litre (g/l) chlorine. The capital and operating cost estimates prepared by Kilborn and Canmet do not include the provision for groundwater monitoring or sampling of these wastes.

The basic flowsheet for the FCL process involves a two-stage leach system. The first stage leach separates out lead which undergoes chlorine crystallization and fused salt electrolysis to produce metal. The copper and silver are separated from the lead chlorine crystalization and, following cementation, the blister quality copper can be sold to a copper refinery.

Zinc undergoes solvent-extraction, purification and electrolysis to produce refined zinc. The purification section of the FCL process is the same as in an electrolytic smelter but the electrolysis section is considerably different in that chlorine gas is used and recycled to chlorination towers where it is able to regenerate ferric-chloride lixiviant for the leach circuit.

The iron undergoes solvent extraction to strip iron from remaining zinc in solution; the iron is recycled back to the leach circuit. Since the iron is not removed through the solvent extraction section, an oxyhydrolysis section is included to produce an iron residue product such as goethite.

In summary, the only similarity between the FCL and the SGPL and electrolytic technology is the purification section which removes impurities before electrolysis. Canmet has estimated that the presence of impurities in zinc electrolyte for the FCL process would be much less significant than in conventional electrolytic technology.

The capital cost estimates for the Ferric Chloride Leach (FCL) process are based on studies conducted by Canmet and Kilborn engineers for a 100,000 tpy zinc smelter treating New Brunswick bulk concentrates. For the purposes of comparative analysis, we have omitted the capital costs for bulk flotation from the published cost estimates in an attempt to analyze comparable zinc smelting technologies. In other words, flotation is a cost assigned to mining and milling rather than to smelting.

The capital and operating cost estimates do not include a cadmium recovery circuit. Hence, cadmium metal is not assigned a credit against the smelter's net operating costs.

The following calculation sets forth the derivation of the capital cost and the annualized capital cost assuming a 20 percent return on the equity investment. This is incorporated in the capital servicing rate of LIBOR plus 3 percent.

1990 Canadian $	$ 290 Mn
Converted to U.S. $ (U.S.$ 1.00/C$ 1.17)	$ 248 Mn
Converted To $/t Zinc	$2480
Inflated To 1995 $ (x 1.19667)	$2968
Capital Relative Cost (1.19/1.20)	$2943

The annualized capital cost at a LIBOR rate of 8.5 plus 3 percent over 15 years is $420.63.

The operating cost estimates for a greenfield New Brunswick smelter using the FCL process have been developed based on a 100,000 tpy zinc smelter with the following metal flowsheet:

	Conc. Grade (%)	Recovery Rate (%)
Zn	30.0	96
Pb	10.4	96
Cu	1.0	95
Ag	278 (g/t)	95

The operating cost estimates prepared by Canmet and Kilborn were published in June 1990 entitled, "Evaluation Of The Canmet Ferric Chloride Leach (FCL) Process For The Treatment Of Complex Base Metal Sulphide Ores". The following table presents the 1990 and 1995 net operating cost estimates by cost components:

NET OPERATING COST ESTIMATES
NEW BRUNSWICK FCL SMELTER
(\$/tonne metal)

	1991	1995
Labor	146.10	168.73
Energy	25.15	30.02
Power	156.54	176.64
Reagents & Supplies	153.38	183.04
Sulfur Credit	(34.65)	(46.50)
By-Product Credit	(128.15)	(171.99)
Transport To Market	40.10	59.35
Working Capital	1.30	1.53
Net Operating Costs:	359.77	400.82

In 1995, the labor cost per tonne is a bit lower than the electrolytic technology, since there is a single bulk concentrate used as a source of feed. In addition, the solvent extraction process used in zinc and iron is somewhat less labor intensive than the leach/purification section of the electrolytic technology.

The fuel and power requirements are higher than in the SGPL and electrolytic technology because of increased power consumption in the lead and zinc electrowinning sections; lead does not undergo electrolysis in either the SG or conventional electrolytic process.

The cost of reagents, supplies and equipment is slightly lower than for an electrolytic smelter, since there are lower cost reagent inputs, such as chlorine and lime, required in the FCL process.

Both the SGPL and the FCL processes produce elemental sulfur of below market quality, so there has been no credit assigned to the sulfur product; an electrolytic smelter would receive a $36.63/tonne of zinc acid credit.

The most significant difference in the three technologies is the by-product credit assigned to the smelter. In the FCL process, marketable refined lead is produced. The SGPL recovers a lead-silver residue which would require refining. Thus, with SGPL a deduction must be made in the value of the lead to cover the refining charge. Copper is recovered in the FCL process through cementation in a filter cake. It is assumed that this cake is of blister quality and would only have to absorb a refining charge. In the conventional electrolytic and SGPL processes, some copper may be recovered, but it would have to be sent to a smelter for processing and, thus, would incur both a smelting and refining charge. In a traditional zinc concentrate, none of the contained copper is paid for. Brunswick lead and zinc concentrates contain copper but is not recovered by zinc smelters. However, a separate copper concentrate is also produced. Under the FCL scenario there would be no separate copper concentrate. Thus, copper would report to the bulk concentrate.

Since there is no metallurgical research advanced to the point where a determination of the marketability of the elemental sulfur can be made, we have used the same assumptions as in the case for the Sherritt Gordon process.

The by-product credit has been calculated based on the typical commercial arrangements at an ISF smelter for bulk concentrates; most of the lead and silver recovered would be paid to the mine. However, since ISF plants do not typically recover copper, none of the copper contained in the New Brunswick bulk concentrates would be paid to the mine. Therefore, about 90 percent of the total by-product credit is attributed to the unpaid for copper and lead.

The calculation of the full cost of the FCL New Brunswick smelter including the 20 percent return on the equity investment, would be as follows:

	$/tonne
Annualized Capital Cost	**421**
Corporate Charge	**19**
Net Operating Cost	**401**
Full Cost:	**$841**

In order to calculate smelter revenue it is necessary to calculate the treatment charge and unpaid for zinc in the bulk concentrate. We have assumed the same treatment charge as in the New Brunswick ISF analysis.

Treatment Charge Base	**$270.00**
Zinc Escalator ($1709 - $1600 = 109 / 10 = 10.9 x 2.00)	**+ 21.80**
Lead Escalator ($908 - 900 = 8 / 10 = 0.8 x 1.55)	**+ 1.24**
Treatment Charge	**$293.04**
Zinc Contained (2205 x 0.30)	**662 lb**
Zinc Recovered (x 0.96)	**635 lb**
Zinc Paid For (2205 x 0.24)	**529 lb**
Unpaid For Zinc (635 - 529)	**106 lb**
Value Of Free Zinc (77.5 c x 106)	**$82.15**
Lead Contained (2205 x .104)	**229 lb**
Lead Recovered (x 0.96)	**220 lb**
Lead Paid For (2205 x .074)	**163 lb**
Unpaid For Lead (220 - 163)	**57 lb**
Value Of Free Lead (41.2 x 57)	**$23.48**
	(Assigned as credit to zinc production cost)
Treatment Charge	**$293.04**
+ Value Of Unpaid For Zinc	**82.15**
Smelter Revenue:	**$375.19**

Because the bulk concentrate contains only 30 percent zinc, the treatment charge plus the value of unpaid zinc of $373.19/tonne of concentrates translates into a high value when converted to a tonne of metal basis. We have used the same treatment charge location premium and metal price premium as in the other New Brunswick smelter revenue simulations. Thus, the revenue per tonne of metal would be as follows:

Base TC + Unpaid Zinc	**$1,302.74**
TC Premium	**27.90**
Metal Premium (6 c/lb)	**132.30**
Total Revenue:	**$1,462.94**

The comparison of full cost to total revenue would be as follows ($/tonne metal):

Total Revenue	**$1,463**
Full Cost	**- 841**
Net Balance:	**+ 622**

Thus, based on the cost and revenue methodology employed, a New Brunswick FCL smelter would appear to be more than viable. However, we must emphasize that there is no actual operating experience with FCL, so that there must be a degree of uncertainty in the cost estimates.

The following exercise will demonstrate the effect on mine profitability when a bulk concentrate is produced and processed using FCL technology. The example will assume the same ore grades, recovery rates and concentrate grades as they appear in the table on page V-10 for selective and bulk concentrates. In both cases, ore production is 1,239,000 Mn tonnes/yr.

1995 GROSS REVENUE
($US Mn)

	Bulk Concentrate	Selective Concentrate
Zinc	0	134.85
Lead	0	20.14
Copper	9.51	7.08
Silver	13.00	11.79
Bulk		
Zinc	179.81	14.98
Lead	33.03	4.43
TOTAL:	$235.35	$193.27

The findings indicate that gross revenues would increase about 21.7 percent if the mine switched to bulk flotation rather than selective concentrate flotation assuming the metal price forecasts are accurate. The revenue increase would be accounted for as follows:

Zinc	29.98
Lead	8.46
Copper	2.43
Silver	1.21
TOTAL:	$42.08 Mn

The next step is to calculate net revenue to the mine by deducting the treatment charges for each metal recovered in the concentrate(s). The following tables present the net revenue calculation for each concentrate and the total net revenue by each flotation method.

ZINC CONCENTRATE
1995 NET REVENUE
(\$US Mn)

	Bulk Concentrate	Selective Concentrates (157,900 t)
Gross Revenue	0	134.85
Zinc % Paid (x 0.85)	n/a	114.62
Less Unpaid For Zinc Recovered By Smelter (.96 - .85)	n/a	- 14.83
Less Treatment Charge (\$275.67 x 157,900 Zn Concs)	n/a	- 43.53
Net Revenue:	0	\$56.26

LEAD CONCENTRATE
1995 NET REVENUE
(\$US Mn)

	Bulk Concentrate	Selective Concentrates (22,180 t)
Gross Revenue	0	20.14
Lead % Paid (x 0.95)	n/a	19.13
Less Unpaid For Lead Recovered By Smelter (0.98 - 0.95)	n/a	- 0.61
Less Treatment Charge (\$211.21 x 22,180 Pb Concs)	n/a	- 4.68
Net Revenue:	0	\$13.84

COPPER CONCENTRATE
1995 NET REVENUE
($US Mn)

	Bulk Concentrate	Selective Concentrates (11,250 t)
Gross Revenue	9.51	7.08
Copper % Paid (x 0.95)	0	6.73
Less Unpaid For Copper In Smelter (0.97 - 0.95)	n/a	- 0.4
Less Smelting Charge ($135 x 11,250 Cu Concs)	n/a	- 1.52
Less Refining Charge (13.5 c/lb x 22.04 x 2590 Cu Metal)	n/a	- 0.77
Net Revenue	0	$4.3

(1) The FCL smelter recovers the copper in the bulk concentrate but would not pay the mine. Thus, the copper revenue accrues to the FCL smelter not the mine.

SILVER
1995 NET REVENUE
($US Mn)

	Bulk Concentrate	Selective Concentrates
Gross Revenue	13.00	11.79
Silver % Paid (x 0.90)	11.70	10.61
Unpaid For Silver In Smelter	n/a	n/a
Net Revenue	$11.70	$10.61

(1) The analysis does not credit unpaid for silver in the smelter revenue. Thus, no cost has been deducted for upaid for silver in the net revenue calculation.

ZINC AND LEAD BULK CONCENTRATE
1995 NET REVENUE
($US Mn)

	Bulk Concentrate	Selective Concentrates
Gross Revenue:		
Zinc	179.81	14.98
Lead	33.03	4.43
Zinc Unit Deduction	6	7
Zinc % Deduction	(.30 - .06) x 179.81	(.33 - .07) x 14.98
Net Zinc Paid (Revenue - % Deduction)	136.65	11.08
Pb Unit Deduction	3	3
Pb % Deduction	(.104 - .03) x 33.03	(.18 - .03) x 4.43
Net Lead Paid (Revenue - % Deduction)	30.59	3.76
Unpaid For Zinc In Smelter (Recovery - Paid %)	(.96 - .80) x 179.81	(.94 - .79) x 14.98
Less Unpaid Zinc Value	- 28.77	- 2.25
Unpaid For Lead In Smelter (Recovery - Paid %)	(.96 - .71) x 33.03	(.96 - .83) x 4.43
Less Unpaid Lead Value	- 8.26	- 0.58
Less Smelting Charge ($293.04 x Bulk Concentrate Production)	- 102.82	- 7.78
Net Revenue:	$27.45	$4.87

SUMMARY TABLE
1995 NET REVENUE EXCLUDING MINING COSTS
($US Mn)

	Bulk Concentrate	Selective Concentrates
Zinc	0	56.26
Lead	0	13.84
Copper	0	4.30
Silver	11.70	10.61
Bulk	27.45	4.87
TOTAL:	$39.15	$89.88

The overall net revenue estimates indicate the extent to which unpaid for metals such as copper and lead accrue to the FCL smelter rather than to the mine. Moreover, there is unpaid for zinc in the bulk concentrate which accounts for a considerable source of revenue. The difference in net revenue between the selective concentrates and bulk concentrate is about $51 Mn in 1995.

The final step is to add the operating costs against the mine's gross revenue less treatment charges to obtain adjusted net revenue for the bulk and selective concentrates.

The operating costs were estimated assuming ore production of 1,239,000 tonnes/yr assuming the ore grades, recovery rates and concentrate grades presented in the table on V-10. The operating costs are slightly lower for the bulk concentrate since the mill would theoretically run a single circuit instead of running four separate circuits at a time. The mining costs would be $60.25 and $61.41/t ore for the bulk and selective concentrates, respectively.

1995 ADJUSTED NET REVENUE INCLUDING MINING COSTS

($US Mn)

	Bulk Concentrate	Selective Concentrates
Gross Revenue	235.35	193.27
Less Treatment Charges	- 196.14	- 103.39
Less Mining Costs	- 74.65	- 76.09
Adjusted Net Revenue:	($35.44)	$13.79

The economic evaluation of the FCL process should include the smelter net revenue since it is assumed that most of the unpaid for metals would be credited against net operating costs. We have estimated net revenue as follows in $/tonne metal.

Total Revenue	$1463
Full Cost	- 841
Net Revenue:	$622

In order to calculate the net revenue value we must multiply net revenue ($622/tonne) times the zinc smelter production (100,000 mt), which equals $62.2 Mn. Finally, we can total the overall net revenue as follows:

Mine	($35.44)
Smelter	62.20
	$26.76

Thus, a comparison of the net revenue for the FCL process and the present mine and smelter flowsheet at the New Brunswick mine indicated that the FCL scheme could potentially increase net revenues by as much as 90 percent. ($26.76 Mn versus $13.79 Mn). However, as we have stated, the capital and operating costs for an FCL smelter are not based on commercial application of the process; a pilot plant is merely in the early stages of development.

The following table presents a summary comparison of a greenfield New Brusnwick smelter with the four technologies. Only the FCL smelter would achieve the target rate of return.

We will now estimate how New Brunswick mineral processing tax incentives can alter this.

NEW BRUNSWICK SMELTER COMPARISON
(1995 $/tonne Zn)

	Electrolytic	ISF	SGPL	FCL
REVENUE				
Base Treatment Charge + Unpaid Zinc	718	929	858	1303
TC Premium	28	28	28	28
Metal Premium	132	132	132	132
Total Revenue:	878	1089	1018	1463
COST				
Annualized Capital Cost	651	482	599	421
Coroporate Charge	19	31	19	19
Net Operating Cost	460	600	487	401
Full Cost:	1130	1113	1105	841
BALANCE				
Total Revenue	878	1089	1018	1463
Less Full Cost	- 1130	- 1113	- 1105	- 841
Net Balance:	(252)	(24)	(87)	622

V.3 New Brunswick Tax Incentives

The government of New Brunswick offers tax benefits in its Metallic Minerals Tax Act to encourage further mineral processing within the Province. Consequently, the capital cost of a new smelter qualifies for a processing allowance deduction against the 2 percent net revenue tax and the 16 percent net profits tax.

The capital cost allowance deduction is equal to 15 percent of the capital cost of the smelter, i.e. the total investment, per year.

Under the net revenue tax, the processing allowance deduction cannot exceed 25 percent of total net revenue.

Under the net profit tax, if the mine owner or operator builds a new smelter, the law allows for 100 percent depreciation, or any lesser amount, as quickly as the owner or operator wishes.

A very important point to note is that if the smelter is built by a mine owner or operator, then tax deductions do not simply apply to the revenues and profits of the smelter. Rather they are applied against the combined revenues and profits of the combined mining and smelting operations. Thus, even if the smelter itself does not generate a profit, the deductions would provide a benefit to the combined mining and smelting operation.

In addition, there is a tax provision which allows for an 8 percent deduction on the book value of the processing facilities or mill if it is integrated with the smelter in the province. For the purposes of analysis, we have not included this provision in our assessment of the tax savings but it would be consistent in all cases with the exception of the FCL process.

In this case, capital investment would need to be made at the mill in order to treat at least 100,000 tonnes of bulk concentrates. This investment could result in a greater tax savings than for the other technologies. Notwithstanding this fact, our primary focus is on smelter profitability in this study and, hence, we have not estimated the potential tax savings for the procssing facilities.

In the following calculations we will assume that the smelter capital allowance is applied at 15 percent per annum based on 1995 costs.

Electrolytic smelter. The capital cost per tonne for this facility was calculated at $4,553. The 15 percent per year deduction would be $683. The deduction from the 2 percent net revenue tax would be worth $14 and from the 16 percent net profits tax would be worth $109.

The total tax saving would be $123, calculated as follows:

Capital Cost/Tonne	**$4,553 x 0.15/year = $683**
Net Revenue Tax	**0.02 x 683 = $13.66**
Net Profit Tax	**0.16 x 683 = 109.28**
Total Tax Saving:	**$122.94**

ISF smelter. The capital cost per tonne for this facility was calculated at $3,376. The tax saving would be as follows:

Capital Cost/Tonne	**$3,376 x 0.15/yr = $506**
Net Revenue Tax	**0.02 x 506 = $10.12**
Net Profits Tax	**0.16 x 506 = 80.96**
Total Tax Saving:	**$91.08**

Sherritt Gordon Pressure Leach smelter. The capital cost per tonne for this facility was calculated at $4,193. The tax saving would be as follows:

Capital Cost/Tonne	**$4,193 x 0.15/yr = $629**
Net Revenue Tax	**0.02 x 629 = $12.58**
Net Profits Tax	**0.16 x 629 = 100.64**
Total Tax Saving:	**$113.22**

Ferric Chloride Leach Smelter. The capital cost per tonne for this facility was calculated at $2,943. The tax saving would be as follows:

Capital Cost/Tonne	**$2,943 x 0.15/yr = $441**
Net Revenue Tax	**0.02 x 441 = $882**
Net Profits Tax	**0.16 x 441 - 70.56**
Total Tax Saving:	**$79.38**

Thus, we see that these potential tax savings are significant. To provide a rough quantification of these benefits, we will assign them as credits against our full production cost calculations to see how they would alter the smelter full cost versus smelter revenue balances. This is, of course, a rather simplistic approach. Profit taxes are not included in any of our cost calculations, thus the inclusion of a tax credit without including a tax would present a somewhat distorted picture. However, if we were to assume that the smelter alone would not produce a profit but that the mine owner or operator that owns the smelter does generate enough profit to realize the full benefit of the smelter tax concessions there is some logic in this approach. With these caveats, we can give some indication of how the tax savings could alter the smelter cost/revenue balance.

	Electrolytic	ISF	SGPL	FCL
Full Cost	1130	1113	1105	841
Tax Saving	- 123	- 91	- 113	- 79
Adjusted Cost	1007	1022	992	762
Revenue	878	1089	1018	1463
Net Balance	- 129	+ 67	+ 26	+ 701

On this basis, three smelter projects could be considered economically viable. The electrolytic smelter would not achieve its target rate of return on equity investment.

The FCL smelter would be far-and-away the most profitable of the four projects. However, as already noted, there is not any operating experience from which to develop cost estimates and, even more importantly, the technology itself has not yet been proven.

V.4 Conclusions

The construction of a new electrolytic zinc smelter in New Brunswick would not appear to be a viable venture. Even with the significant tax saving that would be available the project could not meet a satisfactory rate of return on the equity investment. Furthermore, new Eastern Canadian electrolytic smelter capacity could be achieved at a lower cost through the expansion of Noranda's Valleyfield smelter in Quebec. Lastly, an electrolytic smelter would not be able to treat the bulk zinc/lead concentrates produced in New Brunswick which are currently exported to Europe.

The viability of a new ISF smelter warrants further consideration. Our cost/revenue calculations indicate that such a smelter could achieve a satisfactory rate of return on the invested equity. The issue of concern with an ISF smelter is technological. Brunswick Mining was unable to achieve satisfactory operating results with the ISF it built some years ago and was forced to convert the plant to a lead smelter.

However, it is possible that advances in ISF technology have been achieved in the intervening years which might mean that New Brunswick bulk concentrates could be successfully treated in a new ISF. It is also worth noting that the ISF smelter that Nippon Mining will probably build in Japan would take in zinc-bearing steel mill flue dust along with bulk concentrates. It would be worth examining the possibility of a New Brunswick ISF taking in steel mill flue dust arising in Eastern Canada and Northeastern U.S. Quite possibly such a raw material could be secured at very advantageous terms.

Consequently, we believe it would be worthwhile to establish contact with Imperial Smelting personnel to explore the technological feasibility of an ISF smelter treating New

Brunswick bulk concentrates. Should this examination prove positive, the possibility of also treating steel mill flue dust could be investigated.

Our cost/revenue analysis indicated that a Sherritt Gordon Pressure Leach smelter could achieve the target rate of return after factoring in tax credits. However, it would not quite match the profitability of an ISF. A drawback to a SGPL smelter is that it would have to take in about two-thirds of its zinc feed as zinc concentrates and only one-third as bulk concentrates, whereas an ISF might be able to take in half of its feed as bulk concentrates. This may or may not be a problem. New Brunswick zinc concentrates are presently sent to Valleyfield and to foreign smelters. The concentrates needed for a New Brunswick smelter could probably be taken away from exports without causing feed problems for Valleyfield.

A 100,000 tpy SGPL smelter would be able to take in all of the bulk concentrates currently produced in the Province, i.e. about 30,000 tonnes of contained zinc. However, should the Caribou mine be reopened, another 40,000 tonnes of zinc in bulk concentrates would be available. To handle 70,000 tonnes of zinc in bulk concentrates, a SGPL smelter would have to take in about 140,000 tonnes of zinc in zinc concentrates and would have to have a capacity of 210,000 tpy of zinc. A 150,000 tpy ISF smelter would probably be able to absorb 70,000 tonnes of zinc in bulk concentrates. Thus, a SGPL of 210,000 tpy capacity would face a more difficult task in developing market outlets in North America for that additional 60,000 tpy of zinc.

The Ferric Chloride Leach Process comes out as far-and-away the most attractive investment from a cost/revenue standpoint. However, this is unproven technology and the cost estimates could well be overly optimistic. RSI does not have the technological capability to render a judgement on the commercial feasibility of an FCL smelter.

Perhaps the best way to proceed would be to have an impartial metallurgical expert review the FCL process to determine whether it would have a reasonable chance of achieving technical and commercial viability. Should the judgement be positive, the next consideration would be how long it would take to prove out the technology and when could a commercial plant be brought onstream.

We have already discussed the window of opportunity for the development of new North American zinc smelter capacity in this decade. Our analysis shows there will only be room for about 150,000-20,000 tonnes of new North American capacity in this decade. It could come from incremental expansions at existing smelters or from a new greenfield smelter. If too much time elapses before a decision can be reached on a new greenfield smelter, the probability becomes increasingly likely that incremental expansions will proceed and the available market will be preempted.

APPENDIX A

Base Case Macroeconomic Forecast

UNITED STATES ECONOMIC ASSUMPTIONS

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
GNP, bn 82$	3248.7	3166.0	3279.1	3501.4	3618.7	3717.9	3845.3	4016.9	4117.7	4157.2
% change	1.9	-2.5	3.6	6.8	3.4	2.7	3.4	4.5	2.5	1.0
Consumption, bn 82$	2024.2	2050.7	2146.1	2249.3	2354.8	2446.4	2515.7	2606.5	2656.8	2685.3
% change	1.2	1.3	4.7	4.8	4.7	3.9	2.8	3.6	1.9	1.1
Durables	250.8	252.6	283.1	323.1	355.1	384.4	391.4	418.2	428.0	429.4
% change	2.0	0.8	12.0	14.1	9.9	8.2	1.8	6.8	2.3	0.3
Investment, bn 82$	521.7	471.9	510.4	596.0	627.9	634.1	646.2	682.0	693.1	691.9
Residential	126.5	105.1	149.3	170.9	174.4	195.6	196.4	194.9	187.0	177.1
% change	-7.6	-16.9	42.0	14.5	2.1	12.2	0.4	-0.8	-4.0	-5.3
Non-Res. Structures	148.8	143.3	127.2	143.7	149.5	130.1	122.8	122.4	122.4	122.3
% change	9.3	-3.7	-11.2	13.0	4.0	-13.0	-5.6	-0.3	-0.0	-0.0
Non-Res. Equipment	246.4	223.4	234.0	281.4	304.0	308.3	327.0	364.8	383.7	392.5
% change	1.4	-9.3	4.7	20.3	8.0	1.4	6.0	11.6	5.2	2.3
Chg in Stocks, bn 82$	23.9	-24.6	-6.4	62.2	9.1	5.6	22.8	23.6	23.8	3.0
Ind. Prod. Index, % chg	1.9	-4.4	3.6	9.4	1.7	1.0	4.9	5.4	2.6	0.9
Pers. Disp. Income, % chg	1.6	0.6	3.0	5.8	2.7	3.6	1.5	5.0	2.4	1.1
Unemployment Rate, %	7.6	9.7	9.6	7.5	7.2	7.0	6.2	5.5	5.3	5.5
90 Day T Bill Rate	14.1	10.7	8.6	9.6	7.5	6.0	5.8	6.7	8.1	7.5
Prime Interest Rate	18.9	14.9	10.8	12.0	9.9	8.3	8.2	9.3	10.9	9.9

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GNP, bn 82$	4151.4	4271.8	4403.8	4524.5	4624.5	4749.8	4869.2	4991.7	5117.2	5245.9
% change	-0.1	2.9	3.1	2.7	2.2	2.7	2.5	2.5	2.5	2.5
Consumption, bn 82$	2688.5	2758.4	2837.0	2911.9	2975.1	3042.0	3110.5	3180.5	3252.0	3325.2
% change	0.1	2.6	2.8	2.6	2.2	2.2	2.2	2.2	2.2	2.2
Durables	427.2	443.0	461.6	474.5	486.4	498.6	511.0	523.8	536.9	550.3
% change	-0.5	3.7	4.2	2.8	2.5	2.5	2.5	2.5	2.5	2.5
Investment, bn 82$	643.1	665.6	709.3	741.3	757.6	777.2	798.4	819.6	841.3	863.6
Residential	149.7	151.7	158.7	164.0	166.7	170.9	175.2	179.5	184.0	188.6
% change	-15.5	1.4	4.6	3.4	1.7	2.5	2.5	2.5	2.5	2.5
Non-Res. Structures	113.3	113.7	120.2	127.4	132.8	136.8	140.9	145.1	149.5	153.9
% change	-7.4	0.3	5.7	6.0	4.2	3.0	3.0	3.0	3.0	3.0
Non-Res. Equipment	380.1	400.2	430.5	449.9	458.1	469.5	482.4	495.0	507.8	521.0
% change	-3.2	5.3	7.5	4.5	1.8	2.5	2.8	2.6	2.6	2.6
Chg in Stocks, bn 82$	-11.0	22.2	22.5	13.3	12.7	13.3	14.0	14.7	15.4	16.2
Ind. Prod. Index, % chg	-2.9	4.4	3.2	2.4	1.9	2.5	2.5	2.5	2.5	2.5
Pers. Disp. Income, % chg	-0.6	2.1	2.7	2.6	1.6	2.0	2.0	2.0	2.0	2.0
Unemployment Rate, %	6.8	6.5	5.9	5.4	5.2	5.0	5.0	5.0	5.0	5.0
90 Day T Bill Rate	5.5	5.9	6.8	7.2	7.2	7.0	7.0	7.0	7.0	7.0
Prime Interest Rate	8.9	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5

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INDEX OF INDUSTRIAL PRODUCTION

(% Change)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Food & Beverages	2.3	1.4	2.7	2.3	3.0	2.7	2.6	2.8	2.6	2.0
Chemicals	1.5	-8.3	6.9	4.5	0.0	3.5	5.7	5.4	3.0	1.6
Petroleum	-5.0	-5.2	0.3	3.8	-0.3	6.8	1.1	3.4	2.5	2.2
Fabricated Metals	-1.5	-8.6	2.7	9.1	1.3	-0.7	6.6	6.2	1.0	-1.3
Machinery	9.0	-2.9	0.6	25.6	7.5	4.1	10.6	13.8	7.0	3.9
Electrical	2.8	0.7	5.7	17.2	-1.0	1.3	6.0	6.5	2.9	1.7
Transportation	-5.0	-5.5	12.3	14.2	10.5	5.5	3.1	5.1	1.9	-1.5
Motor Vehicles	-3.9	-8.4	26.7	21.5	9.2	-0.6	1.4	5.8	-1.0	-7.5
Automobiles	0.4	-16.2	38.2	17.1	8.5	-2.0	-6.9	3.2	-2.1	-5.8
Buses & Trucks	4.0	16.9	30.3	33.4	14.0	3.9	11.4	8.9	0.7	-1.9
Trailers & Semis	-6.5	-17.5	24.4	83.4	-10.1	-9.9	14.0	15.7	-16.3	-11.3
Aerospace	-7.2	-5.5	2.7	4.9	10.5	14.1	9.0	3.3	4.2	4.0

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Food & Beverages	1.3	2.7	2.6	2.4	2.3	2.4	2.4	2.4	2.4	2.4
Chemicals	-2.1	4.3	3.3	2.6	2.1	2.7	2.7	2.6	2.6	2.6
Petroleum	-2.6	1.5	1.8	1.3	0.6	1.3	1.0	1.0	1.0	1.0
Fabricated Metals	-6.3	2.1	3.4	1.8	1.0	1.8	1.8	1.8	1.7	1.7
Machinery	-1.8	5.7	8.1	5.5	2.9	3.7	4.0	3.9	4.0	4.0
Electrical	-4.1	5.7	4.5	3.1	2.5	3.3	3.0	3.1	3.1	3.2
Transportation	-4.0	1.7	3.5	3.2	2.8	3.1	3.3	3.4	3.4	3.4
Motor Vehicles	-7.0	1.6	3.8	3.0	2.6	2.8	3.0	3.0	3.1	3.0
Automobiles	-4.6	4.8	5.6	4.2	4.0	4.0	4.4	4.3	4.3	4.3
Buses & Trucks	-9.0	-1.4	3.5	3.6	3.1	3.4	3.5	3.6	3.6	3.6
Trailers & Semis	-22.5	7.7	3.1	-0.3	-1.8	0.8	1.2	1.5	1.5	1.5
Aerospace	-2.0	1.8	3.3	3.4	2.9	3.2	3.3	3.4	3.4	3.3

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OTHER CYCLICAL INDICATORS

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Light Truck Sales	3.7	4.0	4.4	4.5	4.6	4.7	4.7	4.8	4.9	4.9
Auto Sales	8.6	8.7	8.8	9.0	9.2	9.3	9.6	9.9	10.2	10.5
Domestic	6.1	6.2	6.3	6.4	6.5	6.6	6.8	7.0	7.2	7.5
Imports	2.5	2.5	2.6	2.6	2.7	2.7	2.8	2.9	3.0	3.1
Import Share	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Housing Starts	1.19	1.27	1.39	1.50	1.57	1.66	1.75	1.82	1.87	1.91
Conventional	1.06	1.16	1.27	1.36	1.41	1.48	1.54	1.59	1.62	1.64
Mobile Homes	0.13	0.11	0.12	0.14	0.16	0.18	0.21	0.23	0.25	0.27

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CANADIAN ECONOMIC ASSUMPTIONS

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
GNP, bn 82$	313.7	303.6	313.2	332.9	348.8	360.4	374.9	391.4	403.1	406.8
% change	3.7	-3.2	3.2	6.3	4.8	3.3	4.0	4.4	3.0	0.9
Consumption, bn 82$	183.2	178.4	184.5	193.0	203.0	212.0	221.5	231.1	239.9	243.1
% change	2.3	-2.6	3.4	4.6	5.2	4.4	4.5	4.3	3.8	1.4
Investment, bn 82$	69.0	61.4	61.0	62.3	68.1	72.4	79.8	88.0	92.0	91.0
Residential	17.9	15.0	17.5	17.6	19.5	22.0	25.4	26.3	26.9	26.0
% change	6.3	-16.3	17.0	0.5	10.4	12.7	15.5	3.8	2.4	-3.5
Non-Residential	51.1	46.4	43.4	44.6	48.7	50.4	54.5	61.7	65.0	65.0
% change	13.8	-9.1	-6.4	2.8	9.1	3.6	8.1	13.2	5.5	-0.0
Chg in Stocks, bn 82$	0.7	-5.6	-1.6	2.4	1.5	2.2	2.0	0.5	2.5	-1.0
Ind. Prod. Index, % chg	0.5	-10.0	5.4	8.8	4.4	1.3	4.6	4.8	0.1	-2.5
Pers. Disp. Income, % chg	2.5	0.6	-0.6	4.8	3.1	1.7	2.6	5.2	4.9	1.3
Unemployment Rate, %	7.5	11.0	11.7	11.2	10.4	9.5	8.8	7.7	7.5	7.7
Short-Term Interest Rate	18.1	14.1	9.3	11.1	9.5	9.0	8.2	9.4	12.0	12.8

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GNP, bn 82$	399.0	407.3	423.7	439.5	453.7	466.5	478.2	490.2	502.5	515.2
% change	-1.9	2.1	4.0	3.7	3.2	2.8	2.5	2.5	2.5	2.5
Consumption, bn 82$	245.3	250.3	258.0	267.1	276.6	284.9	293.5	302.3	311.3	320.7
% change	0.9	2.0	3.1	3.6	3.6	3.0	3.0	3.0	3.0	3.0
Investment, bn 82$	84.6	88.6	93.5	97.6	102.2	105.3	108.4	111.7	115.0	118.5
Residential	23.4	24.3	26.2	27.5	28.3	28.9	29.4	30.0	30.6	31.2
% change	-10.0	4.0	7.5	5.0	3.0	2.0	2.0	2.0	2.0	2.0
Non-Residential	61.2	64.3	67.4	70.1	73.9	76.4	79.0	81.6	84.4	87.2
% change	-5.9	5.0	4.8	4.1	5.4	3.4	3.4	3.4	3.4	3.4
Chg in Stocks, bn 82$	-4.0	1.0	3.5	2.0	1.2	1.3	1.3	1.3	1.4	1.4
Ind. Prod. Index, % chg	-5.4	3.2	4.0	3.9	3.9	3.0	3.0	3.0	3.0	3.0
Pers. Disp. Income, % chg	1.1	2.7	3.3	3.4	3.7	3.4	2.9	2.9	2.9	2.9
Unemployment Rate, %	10.5	11.4	10.2	9.0	7.8	7.5	7.5	7.5	7.5	7.5
Short-Term Interest Rate	9.4	9.1	9.0	8.5	9.0	9.0	9.0	9.0	9.0	9.0

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EUROPEAN ECONOMIC ASSUMPTIONS

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
GNP, bn 82$	2679.6	2698.6	2746.8	2812.6	2884.7	2962.1	3043.9	3159.6	3267.0	3338.9
% change	0.2	0.7	1.8	2.4	2.6	2.7	2.8	3.8	3.4	2.2
Consumption, bn 82$	1649.8	1662.8	1688.5	1712.6	1757.6	1830.3	1902.1	1980.6	2043.0	2108.0
% change	0.3	0.8	1.5	1.4	2.6	4.1	3.9	4.1	3.1	3.2
Investment, bn 82$	564.9	553.6	557.6	569.3	584.8	607.0	641.5	700.0	745.3	782.4
Residential	145.9	140.9	144.7	146.0	138.5	140.8	143.2	151.1	154.3	163.9
% change	-5.5	-3.4	2.8	0.8	-5.1	1.6	1.7	5.5	2.1	6.2
Non-Residential	419.0	412.7	412.8	423.3	446.2	466.2	498.3	548.9	591.1	618.6
% change	-2.5	-1.5	0.0	2.5	5.4	4.5	6.9	10.2	7.7	4.7
Chg in Stocks, bn 82$	-9.3	2.4	3.1	13.8	9.7	16.3	22.4	32.7	31.8	24.1
Pers. Disp. Income, % chg	-1.4	-1.5	2.3	0.8	8.8	3.7	2.6	1.6	3.1	3.7
Unemployment Rate, %	7.6	9.0	10.2	10.7	10.9	11.0	10.8	10.2	9.2	8.7
German Interest Rate	12.1	9.1	5.8	6.0	5.4	4.6	4.0	4.2	7.1	8.5
French Interest Rate	15.3	14.6	12.5	11.7	9.9	7.7	8.3	7.9	9.4	10.3
Italian Interest Rate	19.6	20.2	18.4	17.3	15.2	13.4	11.5	10.9	12.6	12.5
UK Interest Rate	13.9	12.3	10.1	10.0	12.2	10.9	9.7	10.3	13.9	14.8

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GNP, bn 82$	3389.0	3477.1	3598.8	3706.7	3799.4	3908.5	4022.9	4145.0	4270.8	4400.4
% change	1.5	2.6	3.5	3.0	2.5	2.9	2.9	3.0	3.0	3.0
Consumption, bn 82$	2158.4	2221.3	2278.9	2345.0	2423.7	2494.0	2563.8	2634.3	2706.8	2781.2
% change	2.4	2.9	2.6	2.9	3.4	2.9	2.8	2.8	2.8	2.7
Investment, bn 82$	779.0	796.0	819.9	856.8	897.0	934.7	967.4	998.9	1031.3	1064.9
Residential	161.0	163.5	169.5	173.7	178.7	183.4	188.0	192.7	197.5	202.4
% change	-1.7	1.6	3.7	2.5	2.9	2.6	2.5	2.5	2.5	2.5
Non-Residential	618.0	632.5	650.4	683.1	718.3	751.3	779.5	806.2	833.9	862.4
% change	-0.1	2.3	2.8	5.0	5.2	4.6	3.7	3.4	3.4	3.4
Chg in Stocks, bn 82$	10.5	22.0	29.5	28.6	32.5	33.5	34.5	35.5	36.6	37.7
Pers. Disp. Income, % chg	2.3	2.4	2.4	2.8	3.2	2.9	2.8	2.8	2.8	2.8
Unemployment Rate, %	8.8	9.1	9.0	8.9	8.5	8.4	8.3	8.1	7.9	7.7
German Interest Rate	9.0	7.7	7.4	7.1	6.9	6.5	6.2	6.2	6.2	6.2
French Interest Rate	9.1	7.4	7.1	7.0	6.8	6.6	6.5	6.5	6.5	6.5
Italian Interest Rate	12.0	10.4	9.6	9.0	9.0	8.8	8.5	8.5	8.5	8.5
UK Interest Rate	11.6	10.1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

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EUROPEAN INDUSTRIAL PRODUCTION DETAIL

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Germany	-2.3	-3.2	0.5	2.7	4.1	2.0	0.3	3.6	4.9	5.2
France	-2.1	-0.1	-0.7	-0.4	0.1	0.5	1.9	5.2	4.5	2.5
Italy	-1.5	-3.2	-3.1	3.3	1.1	3.6	4.0	6.0	3.2	0.5
United Kingdom	-5.9	0.2	2.8	4.2	2.4	1.2	5.3	7.3	4.3	-0.2
Belgium	-2.7	0.2	1.7	2.8	1.7	1.1	1.9	5.4	4.6	7.9
Netherlands	-2.0	-3.8	2.1	5.5	3.0	1.4	1.2	1.1	4.7	2.0
Spain	-1.0	-1.2	2.8	1.0	-1.5	2.8	4.8	3.1	4.6	1.4
Sweden	-1.7	-1.8	4.1	8.4	1.6	-0.4	4.1	1.7	1.4	-2.5
Switzerland	-0.3	-5.0	-0.3	4.2	4.3	4.4	1.0	6.4	0.4	3.2
Europe Average	-2.5	-1.9	0.3	2.7	1.9	1.9	2.6	4.9	4.1	2.3

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Germany	3.0	1.7	3.5	3.8	3.2	2.7	2.7	2.7	2.7	2.7
France	0.1	2.7	3.2	3.0	2.6	2.8	2.8	2.8	2.8	2.8
Italy	0.3	2.2	2.3	3.7	2.9	3.0	3.0	3.0	3.0	3.0
United Kingdom	-4.5	3.5	3.4	4.7	4.8	2.5	2.5	2.5	2.5	2.5
Belgium	1.2	0.6	3.4	2.8	3.9	3.0	2.5	2.5	2.5	2.5
Netherlands	3.6	1.1	1.9	2.6	2.2	3.5	3.5	3.5	3.5	3.5
Spain	0.7	4.0	7.3	5.5	4.8	4.5	4.5	4.5	4.5	4.5
Sweden	-2.0	3.2	4.0	3.7	3.3	2.5	2.5	2.5	2.5	2.5
Switzerland	1.3	2.8	3.6	2.4	2.2	2.5	2.5	2.5	2.5	2.5
Europe Average	0.4	2.4	3.4	3.7	3.3	2.9	2.9	2.9	2.9	2.9

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JAPANESE ECONOMIC ASSUMPTIONS

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
GNP, bn 82$	1049.8	1082.5	1117.7	1174.2	1231.4	1262.5	1320.1	1405.2	1470.9	1553.7
% change	3.7	3.1	3.3	5.1	4.9	2.5	4.6	6.4	4.7	5.6
Consumption, bn 82$	603.9	628.7	649.2	667.0	685.1	706.1	736.1	778.5	812.2	848.1
% change	1.2	4.1	3.3	2.7	2.7	3.1	4.2	5.8	4.3	4.4
Durables	35.6	38.9	42.1	47.4	48.1	52.8	58.7	67.4	72.5	76.7
% change	3.0	9.3	8.1	12.7	1.4	9.8	11.2	14.8	7.6	5.8
Investment, bn 82$	329.3	332.3	331.2	346.5	365.3	387.1	426.9	481.3	523.7	578.5
Residential	62.9	62.5	58.8	57.5	58.9	63.7	77.9	88.1	88.1	96.6
% change	-2.7	-0.6	-5.9	-2.2	2.5	8.3	22.1	13.1	0.0	9.6
Non-Residential	266.5	269.8	272.5	289.0	306.4	323.3	349.1	393.2	435.6	481.9
% change	4.7	1.3	1.0	6.1	6.0	5.5	8.0	12.6	10.8	10.6
Chg in Stocks, bn 82$	6.6	5.9	3.1	6.9	11.6	7.2	5.7	13.0	15.8	13.3
Ind. Prod. Index, % chg	0.9	0.4	3.0	9.5	3.7	-0.3	3.4	9.5	6.0	4.8
Pers. Disp. Income, % chg	1.8	2.0	2.9	2.3	2.6	3.6	2.7	4.3	4.5	4.5
Unemployment Rate, %	2.2	2.4	2.7	2.7	2.6	2.8	2.8	2.5	2.3	2.1
Short-Term Interest Rate	7.6	7.0	6.6	6.3	6.6	5.0	3.9	4.0	5.4	7.6

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GNP, bn 82$	1598.2	1661.1	1735.0	1809.5	1873.9	1947.1	2020.6	2097.0	2176.2	2258.4
% change	2.9	3.9	4.4	4.3	3.6	3.9	3.8	3.8	3.8	3.8
Consumption, bn 82$	864.5	889.6	906.2	931.7	959.0	987.8	1017.4	1047.9	1079.4	1111.7
% change	1.9	2.9	1.9	2.8	2.9	3.0	3.0	3.0	3.0	3.0
Durables	77.4	80.1	82.9	86.2	89.2	92.8	96.5	100.3	104.4	108.5
% change	0.9	3.5	3.5	4.0	3.5	4.0	4.0	4.0	4.0	4.0
Investment, bn 82$	616.5	663.1	712.9	762.2	809.5	854.0	896.7	937.0	974.5	1013.5
Residential	100.9	105.2	107.2	109.4	112.4	115.8	119.2	122.8	126.5	130.3
% change	4.5	4.2	1.9	2.1	2.7	3.0	3.0	3.0	3.0	3.0
Non-Residential	515.6	557.9	605.7	652.8	697.1	738.2	777.4	814.2	848.0	883.2
% change	7.0	8.2	8.6	7.8	6.8	5.9	5.3	4.7	4.2	4.1
Chg in Stocks, bn 82$	2.9	3.0	13.1	16.7	14.4	15.0	15.6	16.2	16.9	17.6
Ind. Prod. Index, % chg	2.4	3.4	5.7	4.3	2.5	3.0	3.0	3.0	3.0	3.0
Pers. Disp. Income, % chg	2.9	3.2	2.8	3.8	3.5	3.5	3.5	3.5	3.5	3.5
Unemployment Rate, %	2.3	2.3	2.4	2.6	2.6	2.5	2.5	2.5	2.5	2.5
Short-Term Interest Rate	7.8	7.3	6.7	6.5	6.5	6.2	6.0	5.7	5.7	5.7

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APPENDIX B

Mine Capacity To 1994

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
EUROPE									
Austria									
Bergwerks Union	Bleiberg*	18	18	18	18	18	18	18	0
Denmark									
Greenex	Maarmorilik	70	77	70	48	0	0	0	0
Finland									
Outokumpu	Hammaslanti	3	3	0	0	0	0	0	0
Outokumpu	Keretti	2	2	0	0	0	0	0	0
Outokumpu	Pyhasalmi	17	17	17	17	17	0	0	0
Outokumpu	Vihanti	42	42	42	36	40	21	0	0
Subtotal		64	64	59	53	57	21	0	0
France									
BRGM	Chessy*	0	0	0	0	0	0	12	26
Metaleurop	Les Malines	16	16	12	3	3	0	0	0
Metaleurop	Saint Salvy	22	22	22	22	22	22	22	22
Subtotal		38	38	34	25	25	22	34	48
Germany									
Metaleurop	Bad Grund	25	25	25	25	25	3	0	0
Metaleurop	Goslar	23	12	0	0	0	0	0	0
Metallgesellschaft	Meggen	51	40	40	35	35	35	0	0
Subtotal		99	77	65	60	60	38	0	0
Greece									
Hellenic Chem & Fertilizer	Chalkidiki	23	23	25	27	27	27	27	27
Ireland									
Conroy Petroleum	Galmoy*	0	0	0	0	0	0	0	70
Invernia West	Lisheen*	0	0	0	0	0	0	0	0
Tara Mines (Outokumpu)	Navan	180	180	180	170	170	170	180	180
Subtotal		180	180	180	170	170	170	180	250
Italy									
Samim	Masua	20	18	10	10	5	0	0	0
Samim	Monteponi	7	14	27	27	27	35	35	35
Samim	Raibl	12	12	12	12	12	12	12	12
Subtotal		39	44	49	49	44	47	47	47
Norway									
Bleikvassli Gruber	Bleikvassli	7	7	7	7	7	7	7	7
Norsulfid	Grong	8	8	8	8	8	8	8	8
Norsulfid	Tverefjellet	7	7	7	7	7	7	7	7
Other Mines		5	0	0	0	0	0	0	0
Subtotal		27	22	22	22	22	22	22	22
Portugal									
Pirites Alentejanas	Aljustrel	0	0	0	0	10	24	27	27

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
Spain									
Asturiana de Zinc	Reocin	90	97	100	100	105	111	114	114
Billiton	Aguas Tenidas	0	0	0	0	0	0	0	0
Boliden	Aznalcollar	50	50	54	60	65	65	49	0
Boliden	Los Frailes*	0	0	0	0	0	0	0	0
Exminesa	Rubiales	48	45	41	35	33	0	0	0
Exminesa	Troya	34	37	30	28	26	21	19	17
Metaleurop	Silicatos	31	27	17	17	9	5	0	0
Metaleurop	Santa Barbara	0	0	0	0	0	0	0	0
Almaden y Arrayanes	Nuevo Arrayanes	0	0	0	0	0	0	0	0
Almagrera	Sotiel	27	26	21	21	21	21	21	21
Subtotal		280	282	263	261	259	223	203	152
Sweden									
Boliden	Garpenberg	16	16	19	19	19	19	19	19
Boliden	Kamkberg	0	0	0	0	1	1	1	1
Boliden	Kedtrask	0	0	0	6	0	0	0	0
Boliden	Kristineberg	43	40	25	25	25	25	25	25
Boliden	Laisvall	14	14	14	14	14	14	14	14
Boliden	Other	49	49	31	31	31	31	31	31
Boliden	Saxberget	10	0	0	0	0	0	0	0
Boliden	Stekenjokk	15	0	0	0	0	0	0	0
Stora Kopparbergs	Faluverken	10	12	12	12	12	12	12	12
Vieille-Montagne	Knallagruvan	62	62	62	62	62	72	72	72
Subtotal		219	193	163	169	164	174	174	174
United Kingdom									
Anglesey	Parys Mountain	0	0	0	0	0	7	15	15
Carnon Con. Tin Mines	Cornwall	7	7	7	7	2	0	0	0
Subtotal		7	7	7	7	2	7	15	15
Yugoslavia									
RTB Bor	Bor	65	65	65	70	70	70	70	70
Other Mines		4	4	6	6	6	6	6	6
Subtotal		69	69	71	76	76	76	76	76
Subtotal Europe		1133	1094	1026	985	934	869	823	838
AFRICA									
Algeria									
ENOF	Oued Amizour	0	0	0	0	0	0	0	0
SONAREM	El Abed	8	7	7	7	7	7	7	7
SONAREM	Kherzet-Yousef	10	10	10	10	10	10	10	10
Subtotal		18	17	17	17	17	17	17	17
Burkina Faso									
Perkoa	Perkoa	0	0	0	0	0	0	0	0
Congo									
Socorem	M'Fouati	0	0	0	0	0	0	0	0

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
Morocco									
BRPM	Boumadine	2	3	3	3	3	3	3	3
CMG	Douar Hajar	0	0	5	10	10	30	55	55
CADETAF	Errachidia	7	7	7	7	7	7	7	7
SODIM	Sidi Bou-Othman	2	2	2	2	2	2	2	2
SOMITE	Aguerd N'Tazon	5	5	10	10	10	14	14	14
Soc Min de Djebel Aouam	Mirirtt	3	3	3	3	3	3	3	3
Tigri	Aourir Nough.	2	2	2	2	2	2	2	2
Subtotal		21	22	32	37	37	61	86	86
Namibia									
ISCOR	Rosh-Pinah	38	38	39	38	37	37	37	37
Pb/Zn Namibia	Rossing	4	4	4	4	4	4	4	4
Subtotal		42	42	43	42	41	41	41	41
South Africa									
Anglo/GFSA	Gamsberg	0	0	0	0	0	0	0	0
GFSA/Phelps Dodge	Black Mountain	31	31	28	28	27	27	27	27
Prieska-Anglovaal	Prieska	75	49	25	23	0	0	0	0
Shell South Africa	Pering	35	35	35	35	35	35	35	35
Subtotal		141	115	88	86	62	62	62	62
Tunisia									
Min du Nord Ouest	Fedj El Adoum	3	3	3	3	3	3	3	3
Min du Nord Ouest	Kalaat Senan	1	1	1	1	1	1	1	1
ONM/Metall	Bougrine	0	0	0	0	0	0	35	70
SOTEMI	Le Krib	6	6	6	6	6	6	6	6
Subtotal		10	10	10	10	10	10	45	80
Zaire									
Gecamines	Kipushi	87	91	91	91	91	91	91	91
Zambia									
ZCCM	Kabwe	60	55	45	25	25	25	25	25
Subtotal Africa		379	352	326	308	283	307	367	402
ASIA									
Burma									
No 1 Mining Corp.	Bawdwin	2	2	1	1	1	1	1	1
India									
Gujarat Min. Development	Ambaji	0	0	0	0	0	0	0	0
Hindustan Zinc	Rajpura-Dariba	40	40	40	40	40	40	40	40
	Rampura-Agucha	0	0	0	0	35	55	70	70
	Sarguipalli	0	0	0	0	0	0	0	0
	Zawar	40	40	40	40	40	40	40	40
RSMDC	Deri	0	0	0	0	0	0	0	0
Subtotal		80	80	80	80	115	135	150	150
Iran									
Other Mines		36	25	25	25	25	25	25	25

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
Japan									
Dowa	Hanaoka	39	39	39	30	30	30	30	30
Dowa	Uchinotai	10	10	5	0	0	0	0	0
Kamioka	Mozumi	18	18	18	18	18	18	18	18
Kamioka	Tochibora	41	41	41	41	41	41	41	41
Nippon Zinc	Nakatatsu	11	0	0	0	0	0	0	0
Toyoha	Toyoha	44	44	44	44	44	44	44	44
Yatani	Yatani	4	0	0	0	0	0	0	0
Subtotal		167	152	147	133	133	133	133	133
S. Korea									
Dong Bang	Jang Kun	5	5	5	5	5	5	5	5
Pung Jeun Sangsa	Ul-Jin	4	4	4	4	4	4	4	4
Sam Hwan	Sam Boo	5	5	5	5	5	5	5	5
Young Poong	Yeon Hwa	10	8	8	8	8	8	8	8
Young Poong	Taebaek	3	3	3	3	3	3	3	3
Subtotal		27	25	25	25	25	25	25	25
Saudi Arabia									
Arabian Shield Dev.	Al Masane	0	0	0	0	0	0	0	0
Petromin	Mahd Adh Dhahab	0	2	3	3	3	3	3	3
Subtotal		0	2	3	3	3	3	3	3
Thailand									
Padaeng	Mae Sod	74	81	91	100	100	100	100	100
Turkey									
Cinko-Kursum Metal Sanayii	Aladag	20	20	20	20	20	20	20	20
Cinko-Kursum Metal Sanayii	Cakilpinar	22	22	22	22	22	22	22	22
Etibank/Metall	Rize Cayeli	0	0	0	0	0	0	0	35
Subtotal		42	42	42	42	42	42	42	77
Subtotal Asia		428	409	414	409	444	464	479	514
NORTH AMERICA									
Canada									
Audrey	Mobrun	3	5	6	8	8	11	14	14
Aur	Louvem	0	0	0	0	0	0	0	0
Bethlehem	Goldstream	0	0	0	0	2	4	4	4
Bonanza Metals	Poirier	0	0	0	0	0	0	0	0
BP Canada	Joutel	45	45	40	40	38	35	35	35
Breakwater	Caribou	0	6	18	25	0	0	0	0
Breakwater	Mel	0	0	0	0	0	0	0	0
Breakwater	Estrades	0	0	0	8	15	15	15	15
Brunswick (Noranda)	Bathurst	260	260	260	260	260	260	260	260
Brunswick (Noranda)	Heath Steele	0	0	11	50	48	42	35	35
Cameco/Trimin	Hanson Lake	0	0	0	0	0	0	0	0
Cominco	Pine Point	150	150	150	30	0	0	0	0
Cominco	Polaris	135	140	145	145	155	155	155	155
Cominco	Sullivan	90	90	90	90	108	108	108	108
Curragh	Cirque	0	0	0	0	0	0	60	120
Curragh	Faro	170	170	170	170	170	170	170	170
Curragh	Mt. Hundere	0	0	0	0	24	59	65	65
Deak	MacDonald	0	0	0	0	0	0	25	25
Dickenson	New Denver	1	1	1	1	1	1	1	1

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
Canada (Continued)									
Equinox	J&L	0	0	0	0	0	0	0	0
Falconbridge	Timmins	205	205	200	160	160	150	150	150
Hudson Bay	Callinan	0	0	0	9	25	25	25	25
Hudson Bay	Flin Flon	25	25	25	16	0	0	0	0
Hudson Bay	Ruttan	17	17	20	20	20	20	20	20
Hudson Bay	Snow Lake	23	23	35	35	35	35	35	35
Marshall	Restigouche	0	0	0	0	0	0	0	0
Minnova	Samatosum	0	0	2	4	4	4	4	4
Minnova	Winston Lake	0	38	50	60	55	50	50	50
Nanisivik	Nanisivik	60	60	60	60	57	49	41	36
Newfoundland Zinc	Daniels Harbour	38	33	25	4	0	0	0	0
Noranda	Geco	55	29	33	43	35	28	28	26
Noranda	Isle Dieu	0	30	53	53	53	53	53	53
Noranda	Lyon Lake	26	26	29	26	5	0	0	0
Noranda	Mattabi Ignace	33	33	0	0	0	0	0	0
Noranda	Mattagami	46	33	0	0	0	0	0	0
Normetal	Normetal	0	0	0	3	3	3	3	3
Rio Algom	E. Kemptville	2	2	2	2	2	2	2	2
VSM Exploration	Grevet	0	0	0	0	0	0	0	0
Westmin	Myra Falls (HW)	53	53	53	40	37	40	55	55
Westminer Canada	Gays River	0	0	0	15	15	15	15	15
Subtotal		1437	1474	1478	1377	1335	1334	1428	1481
USA									
Alta Gold	Ward	0	0	0	6	3	0	0	0
Asarco	Leadville	15	15	15	15	15	15	15	15
Asarco	Mascot	60	60	60	60	60	60	60	60
Asarco	New Market	20	20	20	20	20	20	20	20
Asarco	Sweetwater	5	5	5	5	5	5	5	5
Asarco	West Fork	7	11	13	15	15	15	15	15
Boliden	Bald Mountain	0	0	0	0	0	0	0	0
Bunker Hill	Kellogg	0	6	22	23	5	0	0	0
Cominco American	Magmont	14	14	14	14	12	12	12	6
Cominco American	Red Dog	0	0	0	130	270	300	325	325
Cyprus	Pinos Altos	0	0	4	4	4	4	4	4
Doe Run	Brushy Creek	6	6	6	6	6	6	6	6
Doe Run	Buick	35	35	35	35	35	35	35	35
Doe Run	Fletcher	6	6	6	6	6	6	6	6
Doe Run	Viburnum	11	11	11	11	11	11	11	11
Echo Bay	Sunnyside	5	5	5	5	5	5	5	5
Echo Bay/Moneta	Lik	0	0	0	0	0	0	0	0
Equinox	Van Stone	0	0	0	0	12	16	16	16
	Greens Creek	0	0	15	30	30	30	30	30
Hecla	Lucky Friday	4	4	4	4	4	4	4	4
Jersey Miniere Zinc	Gordonsville	48	48	48	48	48	48	48	48
Jersey Miniere Zinc	Jefferson City	15	15	15	15	15	15	15	15
New Butte Mining	Butte Hill	0	0	2	6	2	0	0	0
Pegasus Gold	Montana Tunnels	11	23	20	18	18	18	18	18
Resource Finance	Pend Oreille	0	0	0	0	0	0	0	0
Star-Phoenix	Star Morning	4	4	4	4	4	4	4	4
ZCA	Balmat/Pierre	55	55	55	55	55	55	55	55
Subtotal		321	343	379	535	660	684	709	703
Subtotal North America		1758	1817	1857	1912	1995	2018	2137	2184

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
LATIN AMERICA									
Argentina									
Cerro Castillo	Angela	6	6	6	6	6	6	6	6
Minera Aguilar	El Aguilar	35	35	37	35	35	35	35	35
Subtotal		41	41	43	41	41	41	41	41
Bolivia									
Caballo Blanco	Caballo Blanco	7	7	7	7	7	7	7	7
Minera del Sur	Mina del Sur	24	24	24	24	24	24	24	24
Minera del Sur	Quioma	6	6	9	9	9	9	9	9
Comibol	Bolivar*	0	0	10	35	35	35	35	35
Comibol	Colquiri	0	10	10	10	10	10	10	10
Comibol	Other Mines	2	7	9	9	9	9	9	9
Comibol	San Vicente	0	4	4	4	4	4	4	4
Reminsa	Reminsa	2	2	2	2	2	2	2	2
Tiwanacu	Tiwanacu	5	5	5	5	5	5	5	5
Subtotal		46	65	80	105	105	105	105	105
Brazil									
Inga	Januaria	13	13	13	13	24	35	46	46
CMM	Vazante	77	77	77	77	77	77	77	77
CMM	Morro Agudo	6	11	11	23	23	35	46	46
Paulista de Metais	Boquira	2	2	2	2	2	2	2	2
Subtotal		98	103	103	115	126	149	171	171
Chile									
Minera Catemu	Veta Grande	3	3	3	3	3	3	3	3
LAC Minerals	El Toqui*	18	18	18	20	25	25	25	25
Subtotal		21	21	21	23	28	28	28	28
Honduras									
Breakwater	El Mochito	25	25	34	34	38	40	45	45
Mexico									
Fresnillo	El Monte	5	5	5	5	5	2	0	0
Fresnillo	Fresnillo	4	4	4	4	4	4	4	4
Fresnillo	Naica	23	23	23	23	23	23	23	23
IMMSA	Charcas	25	25	25	40	40	55	55	55
IMMSA	El Tecolote	0	0	0	0	0	0	0	0
IMMSA	San Antonio	15	15	15	15	15	15	15	15
IMMSA	San Martin	62	62	62	62	62	62	62	62
IMMSA	Santa Barbara	36	36	36	36	36	36	36	36
IMMSA	Taxco	30	30	30	30	30	30	30	30
IMMSA	Velardena	6	6	6	6	6	6	6	6
Luismin	Real de Asientos	0	0	0	0	2	5	5	5
Namiquipa	Namiquipa	0	0	0	0	2	2	2	2
Penoles	Gochico	0	0	0	0	0	0	0	0
Penoles	La Industria	3	3	3	3	3	3	3	3
Penoles	La Minita	10	10	10	10	10	10	10	10
Penoles	La Negra	3	5	6	6	6	6	6	6
Penoles/Cyprus	Bismark	0	0	0	0	0	0	50	50
Penoles/Outokumpu	Rey de Plata	0	0	0	0	0	9	9	15

ZINC MINE CAPACITY DATABASE

(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
Mexico (Continued)									
Real de Angeles	Real de Angeles	36	36	36	36	42	49	55	57
San Francisco del Oro	San Francisco	17	17	17	17	17	17	17	17
Negoc. Santa Maria	Santa Maria	6	6	6	6	6	6	6	6
Zimapan	Cuale	8	8	4	0	0	0	0	0
Zinc de Mexico	Parral	3	3	3	3	3	3	3	3
Other Mines		12	12	12	12	12	12	12	12
Subtotal		304	306	303	314	324	355	409	417
Peru									
Centromin	Andaychagua	5	9	15	15	15	15	15	15
Centromin	Casapalca	22	22	22	22	22	22	22	22
Centromin	Cerro de Pasco	150	150	150	150	150	150	150	150
Centromin	Iscaycruz	0	0	0	2	2	2	2	2
Centromin	Morococha	6	6	3	3	3	3	3	3
Centromin	San Cristobal	40	40	40	40	40	40	40	40
Centromin	Yauricocha	15	15	15	15	15	15	15	15
Cia Minera Alianza	Ticapampa	1	1	1	1	1	1	1	1
Cia Minera Atacocha	Atacocha	24	24	24	24	24	24	24	24
Cia Minera Chungar	Aminon	2	2	2	2	2	2	2	2
Cia Minera Cochas	El Extrano	4	4	4	4	4	4	4	4
Cia Minera Colquirrumi	San Agustin	6	6	6	6	6	6	6	6
Cia Minera El Altiplano	Cecilia	6	6	6	6	6	6	6	6
Cia Minera Huacracocha	Huacracocha	3	3	3	3	3	3	3	3
Cia Minera Huampar	Colqui	2	2	2	2	2	2	2	2
Cia Minera Huaron	Huaron	13	13	17	17	6	0	0	0
Cia Minera Milpo	El Porvenir	33	33	33	33	33	33	40	40
Cia Minera Raura	Raura	23	23	25	25	25	25	25	25
Cia Minera San Ignacio	San Vicente	80	80	80	70	65	65	65	65
Cia Minera Santa Luisa	Huanzala	32	32	32	33	33	33	33	33
Cia Minera Santander	Santander	28	28	28	28	28	28	28	28
Cia Minera Santo Toribio	Toribio Jecanca	2	2	2	2	2	2	2	2
Cia Minera Volcan	Carahuarca	24	24	24	24	24	24	24	24
Cia Minera del Madrigal	Madrigal	0	0	1	2	2	2	2	2
Cia de Minas Recuperada	Huachocolpa	8	8	4	4	4	4	4	4
Corp Minera Noperu	Quiruvilca	11	13	16	16	16	16	16	16
Maria Helena	Huarita	0	0	2	2	2	2	2	2
Minas del Arcata	Arcata	1	1	1	4	4	4	4	4
Minera Cecibar	Cecibar	5	5	5	5	5	5	5	5
Perubar	Graciela	14	28	28	36	63	57	43	0
Soc Minera Austria Duvaz	Austria Duvaz	4	4	4	4	4	4	4	4
Soc Minera Carolina	Hualgayoc	4	4	4	4	4	4	4	4
Soc Minera El Brocal	Colquijirca	18	18	23	23	23	23	23	23
Soc Minera Gran Bretana	Contonga	7	7	7	7	7	7	7	7
Soc Minera Yauli SA	Alpamina	5	5	5	5	5	5	5	5
Other Mines		62	62	62	62	62	62	62	62
Subtotal		660	680	696	701	712	700	693	650
Subtotal Latin America		1195	1241	1280	1333	1374	1418	1492	1457

ZINC MINE CAPACITY DATABASE
(000 tonnes/year)

COMPANY	LOCATION	1987	1988	1989	1990	1991	1992	1993	1994
OCEANIA									
Australia									
Aberfoyle	Hellyer	16	26	50	90	125	130	130	130
Aberfoyle	Que River	40	33	33	27	9	0	0	0
Consortium/Exxon	Scuddles	0	0	0	30	95	95	100	100
Aztec Mining	Woodcutters	20	20	36	42	42	42	42	42
CRA	Century	0	0	0	0	0	0	0	0
CRA (Enterprise)	Cobar	28	20	20	20	20	20	20	20
CRA (Enterprise)	The Peak	0	0	0	0	0	0	3	3
Denehurst	Woodlawn	49	38	40	44	52	52	52	52
Diversified Min Resources	Silver King	0	0	0	0	0	0	0	0
Falcona Exploration	Mount Garnett	0	0	0	0	0	0	0	0
Macquarie Resources	Benambra	0	0	0	8	8	8	8	8
Minerals Mining & Metallurgy	So. Broken Hill	12	12	12	12	12	12	12	12
MIM	Hilton	11	11	30	45	50	60	70	75
MIM	McArthur River	0	0	0	0	0	0	0	0
MIM	Mt Isa	200	200	180	170	170	170	170	170
Pancontinental	Lady Loretta	0	0	0	0	0	0	0	0
Pancontinental	Thalanga	0	0	0	23	37	41	44	48
Pasminco	Beltana	20	10	10	10	0	0	0	0
Pasminco	Dugald River	0	0	0	0	0	0	0	0
Pasminco	Elura	88	88	88	88	88	88	88	88
Pasminco	Rosebery	62	62	62	62	62	62	62	62
Pasminco (North)	Broken Hill	44	44	44	44	44	44	44	44
Pasminco (ZC)	Broken Hill	162	162	162	162	162	162	162	162
Pillara	Blendevale	0	0	0	0	0	0	0	0
Pinnacle Joint Venturers	Cadjebut	0	29	45	55	61	61	61	61
Plutonic/Lachlan	Balcooma	0	0	0	0	0	0	0	0
Teutonic Bore Joint Venture	Teutonic Bore	0	0	0	0	0	0	0	0
Western Mining	Walford Creek	0	0	0	0	0	0	0	0
Subtotal		752	755	812	932	1037	1047	1068	1077
TOTAL NONSOCIALIST WORLD		5645	5668	5715	5879	6067	6123	6366	6472

* Expansion Plan Not Confirmed.

APPENDIX C

Smelter Capacity To 1994

ZINC SMELTER CAPACITY DATABASE

(000 tonnes/year)

Company	Location	1987	1988	1989	1990	1991	1992	1993	1994
EUROPE									
Austria									
Bleiberger	Gallitz	25	25	25	25	25	0	0	0
Belgium									
VM/MHO	Hoboken-Overpelt	135	135	135	135	135	135	135	135
VM/MHO	Balen, Antwerp	180	180	180	180	180	180	180	180
Subtotal		315	315	315	315	315	315	315	315
Finland									
Outokumpu	Kokkola	160	165	165	170	170	170	170	170
France									
Metaleurop	Noyelles-Godault ISF	110	110	110	110	110	110	110	110
VM/MHO	Auby-Les-Douai	150	205	205	205	205	205	205	205
VM/MHO	Viviez	50	0	0	0	0	0	0	0
Subtotal		310	315	315	315	315	315	315	315
Germany									
Berzelius	Duisburg ISF	80	80	80	80	100	100	100	100
Metaleurop	Harlingerode	70	0	0	0	0	0	0	0
Metaleurop	Nordenham	120	120	120	120	120	120	120	120
Ruhr Zink	Datteln	145	145	145	175	200	200	200	200
Subtotal		415	345	345	375	420	420	420	420
Italy									
SAMIM SPA	Porto Vesme ISF/EL	153	153	153	153	153	153	153	153
Metaleurop	Crotone	100	100	100	100	100	100	100	100
Subtotal		253	253	253	253	253	253	253	253
Netherlands									
Billiton	Budel	200	200	200	200	200	200	200	200
Norway									
Norzink AS	Odda	120	140	140	140	140	140	140	140
Spain									
Asturiana	San Juan de Nieva	200	220	220	220	255	320	320	320
Espanola	Cartagena	60	60	66	66	66	66	66	66
Subtotal		260	280	286	286	321	386	386	386
Portugal									
Inga	Barreiro	11	11	11	11	11	24	24	24
United Kingdom									
Pasminco	Avonmouth ISF	90	90	90	95	105	105	105	105
Yugoslavia									
All Primary Smelters ISF/EL		120	120	120	120	120	120	120	120
Subtotal Europe		2279	2259	2265	2305	2395	2448	2448	2448

ZINC SMELTER CAPACITY DATABASE
(000 tonnes/year)

Company	Location	1987	1988	1989	1990	1991	1992	1993	1994
AFRICA									
Algeria									
SN Siderurgie	Ghazaouet	38	38	30	30	30	30	30	30
South Africa									
Zinc Corp SA	Vogelstruisbult	96	92	92	92	92	92	92	92
Zaire									
Gecamines	Kolwezi	65	65	65	65	65	65	65	65
Zambia									
ZCCM	Kabwe	25	25	25	25	25	25	25	25
Subtotal Africa		224	220	212	212	212	212	212	212
LATIN AMERICA									
Argentina									
Emp Sulfacid	Fray Luis Beltran	33	33	33	33	33	33	33	33
Brazil									
Inga	Itaguai*	27	27	36	45	54	72	110	110
CMM	Tres Marias*	72	72	72	72	72	72	72	72
Cia Paraibuna	Juiz de Fora*	55	55	55	57	72	72	75	75
Subtotal		154	154	163	174	198	216	257	257
Mexico									
IMMSA	San Luis Potosi	113	113	113	113	113	113	113	113
Penoles	Torreon	100	100	100	105	115	130	130	180
Subtotal		213	213	213	218	228	243	243	293
Peru									
Centromin	La Oroya	69	69	69	69	69	69	69	69
Minero Peru	Cajamarquilla*	102	102	102	102	102	102	102	102
Subtotal		171	171	171	171	171	171	171	171
Subtotal Latin America		571	571	580	596	630	663	704	754
NORTH AMERICA									
United States									
Big River	Sauget	79	79	79	82	82	82	82	82
Jersey Miniere	Clarksville	96	96	96	96	96	96	96	96
ZCA	Bartlesville	54	54	54	54	54	54	54	54
	Monaca	101	101	101	123	146	146	146	146
Subtotal		330	330	330	355	378	378	378	378
Canada									
CEZ/Noranda	Valleyfield	230	230	230	230	230	230	230	230
Cominco	Trail	272	272	290	290	290	290	290	290
Falconbridge	Timmins	133	133	133	133	133	133	133	133
Hudson Bay	Flin Flon	84	84	84	84	84	84	84	84
Subtotal		719	719	737	737	737	737	737	737
Subtotal North America		1049	1049	1067	1092	1115	1115	1115	1115

ZINC SMELTER CAPACITY DATABASE
(000 tonnes/year)

Company	Location	1987	1988	1989	1990	1991	1992	1993	1994
ASIA									
Japan**									
Akita Zinc	Iijima***	156	156	156	156	156	156	156	156
Hachinohe	Hachinohe ISF	81	81	101	101	101	101	101	101
Mitsubishi	Akita	97	106	106	106	106	106	106	106
Mitsui	Hikoshima****	84	84	84	84	84	84	84	84
	Kamioka	72	72	72	72	72	72	72	72
Nikko Zinc	Mikkaichi*****	100	100	100	100	100	100	100	100
Nippon/Mitsui	Tomakomai*	0	0	0	0	0	0	0	120
Sumiko ISP	Harima ISF	79	79	79	79	79	79	79	79
Toho Zinc	Annaka	139	139	139	139	139	139	139	139
Subtotal		808	817	837	837	837	837	837	957
South Korea									
Korea Zinc	Onsan	150	165	165	170	180	190	200	200
Young Poong	Seakpho	55	62	75	85	85	85	85	85
Subtotal		205	227	240	255	265	275	285	285
India									
Cominco Binani	Kerala	14	20	20	20	20	20	20	20
Hindustan Zinc	Chanderija ISF	0	0	0	0	35	55	70	70
	Debari	49	49	49	49	49	49	49	49
	Vishakhaptnam	30	30	30	30	30	30	30	30
Hindustan Chemicals	Gujarat*	0	0	0	0	0	0	20	20
Subtotal		93	99	99	99	134	154	189	189
Iran									
Iran Pb/Zn Co	Zanjan*	0	0	0	0	0	0	0	0
Research/Engr	Yazd*	0	0	0	0	0	0	0	0
Subtotal		0	0	0	0	0	0	0	0
Thailand									
Paedang	Mae Sod*	60	72	72	72	72	72	72	72
	Thai Coast*	0	0	0	0	0	0	0	0
Subtotal		60	72	72	72	72	72	72	72
Turkey									
Cinko Kursun	Kayseri	25	25	25	25	25	25	30	30
Subtotal Asia		1191	1240	1273	1288	1333	1363	1413	1533
Australia									
Pasminco	Risdon*	214	214	220	220	220	220	220	220
	Cockle Creek ISF	80	80	80	80	80	80	80	80
	Port Pirie	45	45	45	45	45	45	45	45
Subtotal		339	339	345	345	345	345	345	345
TOTAL NON-SOCIALIST WORLD		5653	5678	5742	5838	6030	6146	6237	6407

* Expansion Plan Not Confirmed.

** Japanese Rated Capacity; Actual Effective Capacity About 700,000 MT.

*** Expansion Plan to Increase Capacity to 240K Not Confirmed.

**** Expansion Plan to Increase Capacity to 139K Not Confirmed.

***** Permanent Closure Plan Under Consideration.

APPENDIX D

Base Case Zinc Market Forecast Tables

WORLD ZINC FORECAST SUMMARY

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Consumption	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
% Change	-1.5	-4.2	7.6	3.2	0.9	3.1	3.2	4.7	-1.0	1.0
Mine Capacity	5437.0	5588.0	5493.0	5604.0	5584.0	5626.0	5645.0	5668.0	5715.0	5879.0
Operating Rate	82.0	86.0	87.8	91.0	92.3	88.5	91.2	90.3	91.6	91.0
Mine Production	4459.0	4804.0	4823.0	5100.0	5152.0	4978.0	5149.0	5120.0	5237.0	5350.0
% Change	-1.2	7.7	0.4	5.7	1.0	-3.4	3.4	-0.6	2.3	2.2
Refined Production	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
% Change	1.8	-4.9	6.8	6.1	2.1	-2.8	4.2	3.6	-0.4	-0.7
Inventory Level	638.0	595.0	442.0	449.0	440.0	450.6	411.7	349.5	430.6	391.7
Months Consumption	1.73	1.69	1.16	1.15	1.11	1.11	0.98	0.79	0.99	0.89
LME Price, c/lb	38.9	33.7	34.7	40.5	36.2	34.3	36.2	56.3	77.6	68.8
% Change	12.9	-13.4	3.0	16.5	-10.4	-5.2	5.4	55.4	38.0	-11.3
Real Price, 1990 c/lb	48.3	40.2	40.7	46.5	41.3	39.7	40.9	62.1	81.5	68.8

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Consumption	5284.3	5471.7	5650.0	5779.4	5884.1	5964.3	6091.0	6223.7	6373.6	6479.6
% Change	0.1	3.5	3.3	2.3	1.8	1.4	2.1	2.2	2.4	1.7
Mine Capacity	6067.0	6123.0	6366.0	6472.0	6541.6	6655.3	6787.0	6924.3	7118.0	7307.9
Operating Rate	88.6	88.2	88.1	88.9	89.0	89.3	89.5	89.9	90.3	90.6
Mine Production	5374.6	5400.0	5609.3	5756.3	5820.2	5943.1	6071.4	6221.7	6431.0	6619.0
% Change	0.5	0.5	3.9	2.6	1.1	2.1	2.2	2.5	3.4	2.9
Refined Production	5340.8	5419.8	5635.0	5789.3	5863.5	5976.7	6103.8	6245.5	6442.0	6577.7
% Change	3.0	1.5	4.0	2.7	1.3	1.9	2.1	2.3	3.1	2.1
Inventory Level	528.2	536.2	551.2	561.1	540.5	532.9	505.7	467.5	455.9	454.0
Months Consumption	1.20	1.18	1.17	1.17	1.10	1.07	1.00	0.90	0.86	0.84
LME Price, c/lb	50.8	54.8	66.0	69.7	73.1	77.0	81.2	86.1	91.0	111.4
% Change	-26.3	8.0	20.4	5.6	4.9	5.3	5.3	6.1	5.7	22.4
Real Price, 1990 c/lb	49.6	51.6	59.8	60.8	61.5	62.3	63.1	64.3	65.4	76.9

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UNITED STATES CONSUMPTION BY END USE

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Galvanize	465.0	380.0	450.0	465.0	480.0	529.0	550.0	559.0	583.0	545.0
% Change	9.4	-18.3	18.4	3.3	3.2	10.2	4.0	1.6	4.3	-6.5
Diecast	209.8	208.4	216.8	228.4	214.0	230.7	229.0	263.0	220.0	209.0
% Change	-3.7	-0.7	4.0	5.4	-6.3	7.8	-0.7	14.8	-16.3	-5.0
Brass	158.2	117.6	138.2	161.6	131.0	135.0	139.0	146.0	130.0	120.0
% Change	8.2	-25.7	17.5	16.9	-18.9	3.1	3.0	5.0	-11.0	-7.7
Other Uses	102.2	94.6	129.0	125.0	137.0	104.3	134.0	121.0	127.0	123.0
% Change	13.6	-7.4	36.4	-3.1	9.6	-23.9	28.5	-9.7	5.0	-3.1
Total Consumption	935.2	800.6	934.0	980.0	962.0	999.0	1052.0	1089.0	1059.0	997.0
% Change	6.4	-14.4	16.7	4.9	-1.8	3.8	5.3	3.5	-2.8	-5.9

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Galvanize	519.2	550.6	571.5	613.1	625.3	628.8	638.0	641.1	656.4	680.1
% Change	-4.7	6.1	3.8	7.3	2.0	0.6	1.5	0.5	2.4	3.6
Diecast	206.0	218.8	224.8	230.5	222.2	225.3	224.5	224.9	226.4	229.1
% Change	-1.4	6.2	2.7	2.5	-3.6	1.4	-0.3	0.2	0.7	1.2
Brass	113.7	122.0	118.6	123.7	121.5	121.0	121.7	122.0	123.3	125.4
% Change	-5.3	7.3	-2.8	4.3	-1.8	-0.4	0.6	0.3	1.1	1.7
Other Uses	111.0	119.9	133.8	118.0	122.5	113.8	113.2	119.5	127.4	121.9
% Change	-9.7	8.0	11.7	-11.8	3.8	-7.1	-0.5	5.6	6.6	-4.3
Total Consumption	949.9	1011.4	1048.8	1085.3	1091.6	1088.8	1097.3	1107.5	1133.5	1156.4
% Change	-4.7	6.5	3.7	3.5	0.6	-0.3	0.8	0.9	2.4	2.0

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REFINED ZINC CONSUMPTION BY REGION

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
United States	935.2	800.6	934.0	980.0	962.0	999.0	1052.0	1089.0	1059.0	997.0
% Change	6.4	-14.4	16.7	4.9	-1.8	3.8	5.3	3.5	-2.8	-5.9
Canada	140.0	120.0	144.0	146.0	156.0	155.0	158.0	159.0	148.0	126.0
% Change	5.3	-14.3	20.0	1.4	6.8	-0.6	1.9	0.6	-6.9	-14.9
Europe	1611.0	1563.0	1645.0	1683.0	1665.0	1703.0	1733.0	1854.0	1846.0	1912.0
% Change	-7.0	-3.0	5.2	2.3	-1.1	2.3	1.8	7.0	-0.4	3.6
Japan	699.1	703.0	771.0	774.0	780.0	753.0	729.0	774.0	769.0	814.0
% Change	-7.0	0.6	9.7	0.4	0.8	-3.5	-3.2	6.2	-0.6	5.9
S. Korea	78.5	94.4	113.2	123.0	125.0	154.0	179.0	173.0	196.0	227.0
% Change	15.4	20.3	19.9	8.7	1.6	23.2	16.2	-3.4	13.3	15.8
Other Countries	958.2	955.0	948.8	998.0	1057.0	1126.0	1196.0	1237.0	1213.0	1205.0
% Change	3.5	-0.3	-0.6	5.2	5.9	6.5	6.2	3.4	-1.9	-0.7
Non-Socialist World	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
% Change	-1.5	-4.2	7.6	3.2	0.9	3.1	3.2	4.7	-1.0	1.0

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	949.9	1011.4	1048.8	1085.3	1091.6	1088.8	1097.3	1107.5	1133.5	1156.4
% Change	-4.7	6.5	3.7	3.5	0.6	-0.3	0.8	0.9	2.4	2.0
Canada	125.5	129.9	135.6	143.4	147.4	150.2	153.2	156.3	159.6	163.0
% Change	-0.4	3.5	4.4	5.8	2.8	1.9	2.0	2.0	2.1	2.1
Europe	1915.1	1957.3	1999.3	2019.3	2057.2	2080.8	2115.0	2151.0	2177.6	2202.1
% Change	0.2	2.2	2.1	1.0	1.9	1.1	1.6	1.7	1.2	1.1
Japan	850.1	874.1	898.5	900.8	905.0	904.3	921.0	938.5	968.0	956.6
% Change	4.4	2.8	2.8	0.3	0.5	-0.1	1.8	1.9	3.1	-1.2
S. Korea	255.2	265.5	280.0	291.4	302.6	312.2	328.0	342.7	358.5	374.3
% Change	12.4	4.0	5.5	4.1	3.9	3.2	5.1	4.5	4.6	4.4
Other Countries	1188.5	1233.5	1287.9	1339.2	1380.2	1427.9	1476.5	1527.7	1576.4	1627.2
% Change	-1.4	3.8	4.4	4.0	3.1	3.5	3.4	3.5	3.2	3.2
Non-Socialist World	5284.3	5471.7	5650.0	5779.4	5884.1	5964.3	6091.0	6223.7	6373.6	6479.6
% Change	0.1	3.5	3.3	2.3	1.8	1.4	2.1	2.2	2.4	1.7

	10 Year Annual Average % Growth Rates Period Ending									
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	0.2	2.4	1.2	1.0	1.3	0.9	0.4	0.2	0.7	1.5
Canada	-1.1	0.8	-0.6	-0.2	-0.6	-0.3	-0.3	-0.2	0.8	2.6
Japan	1.7	2.3	2.0	1.8	2.1	2.0	2.0	1.5	1.7	1.4
Europe	2.0	2.2	1.5	1.5	1.5	1.8	2.4	1.9	2.3	1.6
South Korea	12.5	10.9	9.5	9.0	9.2	7.3	6.2	7.1	6.2	5.1
Other Countries	2.2	2.6	3.1	3.0	2.7	2.4	2.1	2.1	2.7	3.0
World Total	1.8	2.6	2.2	2.1	2.2	2.0	1.9	1.6	2.0	2.1

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ZINC MINE AND REFINED PRODUCTION
(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Mine Capacity	5437.0	5588.0	5493.0	5604.0	5584.0	5626.0	5645.0	5668.0	5715.0	5879.0
Operating Rate	82.0	86.0	87.8	91.0	92.3	88.5	91.2	90.3	91.6	91.0
Mine Production	4459.0	4804.0	4823.0	5100.0	5152.0	4978.0	5149.0	5120.0	5237.0	5350.0
% Change	-1.2	7.7	0.4	5.7	1.0	-3.4	3.4	-0.6	2.3	2.2
- CPE Net Imp Ore/Conc	107.0	119.0	164.0	176.0	137.0	101.0	103.0	75.0	50.0	42.0
- Direct Use of Oxide	70.0	50.0	50.0	64.0	69.0	30.0	15.0	5.0	4.0	4.0
= Primary Refined Prod	4266.0	3993.0	4260.0	4559.0	4672.0	4560.0	4765.0	4941.0	4907.0	4849.0
+ Secondary Production	276.0	325.0	352.0	333.0	324.0	295.0	293.0	299.0	310.0	334.0
= Total Refined Prod	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
% Change	1.8	-4.9	6.8	6.1	2.1	-2.8	4.2	3.6	-0.4	-0.7

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Mine Capacity	6067.0	6123.0	6366.0	6472.0	6541.6	6655.3	6787.0	6924.3	7118.0	7307.9
Operating Rate	88.6	88.2	88.1	88.9	89.0	89.3	89.5	89.9	90.3	90.6
Mine Production	5374.6	5400.0	5609.3	5756.3	5820.2	5943.1	6071.4	6221.7	6431.0	6619.0
% Change	0.5	0.5	3.9	2.6	1.1	2.1	2.2	2.5	3.4	2.9
- CPE Net Imp Ore/Conc	0.0	0.0	0.0	0.0	0.0	40.0	60.0	80.0	120.0	150.0
- Direct Use of Oxide	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
= Primary Refined Prod	5008.1	5072.0	5268.8	5406.9	5466.9	5567.5	5683.1	5814.4	6001.2	6127.9
+ Secondary Production	332.7	347.8	366.2	382.3	396.5	409.2	420.7	431.1	440.8	449.8
= Total Refined Prod	5340.8	5419.8	5635.0	5789.3	5863.5	5976.7	6103.8	6245.5	6442.0	6577.7
% Change	3.0	1.5	4.0	2.7	1.3	1.9	2.1	2.3	3.1	2.1

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ZINC MARKET BALANCE & INVENTORIES

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Refined Consumption	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
Refined Production	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
CPE Net Imports Metal	64.0	154.0	238.0	245.0	249.0	45.0	-13.0	43.0	42.0	-39.0
Market Balance	90.0	-47.0	-125.0	-53.0	2.0	-80.0	24.0	-89.0	-56.0	-59.0
Inventory Change	52.0	-43.0	-153.0	7.0	-9.0	10.6	-38.9	-62.2	81.1	-38.9
Unexplained Metal	38.0	-4.0	28.0	-60.0	11.0	-90.6	62.9	-26.8	-137.1	-20.1
Inventory Level	638.0	595.0	442.0	449.0	440.0	450.6	411.7	349.5	430.6	391.7
Months Consumption	1.73	1.69	1.16	1.15	1.11	1.11	0.98	0.79	0.99	0.89

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Refined Consumption	5284.3	5471.7	5650.0	5779.4	5884.1	5964.3	6091.0	6223.7	6373.6	6479.6
Refined Production	5340.8	5419.8	5635.0	5789.3	5863.5	5976.7	6103.8	6245.5	6442.0	6577.7
CPE Net Imports Metal	-80.0	-60.0	-30.0	0.0	0.0	20.0	40.0	60.0	80.0	100.0
Market Balance	136.5	8.0	15.0	9.9	-20.6	-7.6	-27.3	-38.2	-11.6	-1.9
Inventory Change	136.5	8.0	15.0	9.9	-20.6	-7.6	-27.3	-38.2	-11.6	-1.9
Unexplained Metal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inventory Level	528.2	536.2	551.2	561.1	540.5	532.9	505.7	467.5	455.9	454.0
Months Consumption	1.20	1.18	1.17	1.17	1.10	1.07	1.00	0.90	0.86	0.84

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WORLD ZINC MARKET PRICES AND COST TRENDS

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
LME Price, cents/lb	38.9	33.7	34.7	40.5	36.2	34.3	36.2	56.3	77.6	68.8
% Change	12.9	-13.4	3.0	16.5	-10.4	-5.2	5.4	55.4	38.0	-11.3
US Producer Price, c/lb	44.5	38.5	41.4	48.6	40.4	38.0	41.9	60.2	82.0	74.6
% Change	19.0	-13.6	7.6	17.4	-16.9	-5.9	10.3	43.6	36.3	-9.1
LME Price, 1990 c/lb	48.3	40.2	40.7	46.5	41.3	39.7	40.9	62.1	81.5	68.8
LME Price, Stg/tonne	426.7	425.6	505.1	669.6	614.9	516.0	487.8	696.8	1045.2	854.3
% Change	30.6	-0.3	18.7	32.6	-8.2	-16.1	-5.5	42.8	50.0	-18.3
Cost Indicators:										
Floor, Swing Facilities	32.8	33.1	33.6	34.0	34.0	35.4	36.8	38.2	39.8	45.0
Target, New Facilities	42.8	43.3	44.4	45.7	47.0	48.9	50.8	52.9	55.0	62.2

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
LME Price, cents/lb	50.8	54.8	66.0	69.7	73.1	77.0	81.2	86.1	91.0	111.4
% Change	-26.3	8.0	20.4	5.6	4.9	5.3	5.3	6.1	5.7	22.4
US Producer Price, c/lb	52.4	58.4	70.4	74.0	77.3	81.2	85.2	90.0	94.8	114.7
% Change	-29.8	11.6	20.4	5.2	4.5	4.9	5.0	5.7	5.3	21.0
LME Price, 1990 c/lb	49.6	51.6	59.8	60.8	61.5	62.3	63.1	64.3	65.4	76.9
LME Price, Stg/tonne	649.9	695.8	807.2	838.8	902.6	967.8	1037.4	1119.8	1203.6	1472.7
% Change	-23.9	7.1	16.0	3.9	7.6	7.2	7.2	7.9	7.5	22.4
Cost Indicators:										
Floor, Swing Facilities	51.1	49.0	54.6	56.8	59.1	61.5	63.9	66.5	69.1	71.9
Target, New Facilities	68.0	66.0	72.1	75.0	78.0	81.1	84.4	87.8	91.3	94.9

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APPENDIX E

Bear Case Zinc Market Forecast Tables

WORLD ZINC FORECAST SUMMARY

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Consumption	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
% Change	-1.5	-4.2	7.6	3.2	0.9	3.1	3.2	4.7	-1.0	1.0
Mine Capacity	5437.0	5588.0	5493.0	5604.0	5584.0	5626.0	5645.0	5668.0	5715.0	5879.0
Operating Rate	82.0	86.0	87.8	91.0	92.3	88.5	91.2	90.3	91.6	91.0
Mine Production	4459.0	4804.0	4823.0	5100.0	5152.0	4978.0	5149.0	5120.0	5237.0	5350.0
% Change	-1.2	7.7	0.4	5.7	1.0	-3.4	3.4	-0.6	2.3	2.2
Refined Production	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
% Change	1.8	-4.9	6.8	6.1	2.1	-2.8	4.2	3.6	-0.4	-0.7
Inventory Level	638.0	595.0	442.0	449.0	440.0	450.6	411.7	349.5	430.6	391.7
Months Consumption	1.73	1.69	1.16	1.15	1.11	1.11	0.98	0.79	0.99	0.89
LME Price, c/lb	38.9	33.7	34.7	40.5	36.2	34.3	36.2	56.3	77.6	68.8
% Change	12.9	-13.4	3.0	16.5	-10.4	-5.2	5.4	55.4	38.0	-11.3
Real Price, 1990 c/lb	48.3	40.2	40.7	46.5	41.3	39.7	40.9	62.1	81.5	68.8

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Consumption	5284.3	5417.8	5564.8	5661.4	5778.3	5812.4	5890.7	5955.3	6075.5	6152.0
% Change	0.1	2.5	2.7	1.7	2.1	0.6	1.3	1.1	2.0	1.3
Mine Capacity	6067.0	6123.0	6366.0	6472.0	6472.0	6497.0	6561.8	6656.9	6807.1	6950.3
Operating Rate	88.6	88.2	87.4	87.7	87.3	88.3	88.9	89.5	89.7	90.0
Mine Production	5374.6	5400.0	5565.7	5678.6	5647.4	5733.9	5830.7	5958.4	6109.3	6256.5
% Change	0.5	0.5	3.1	2.0	-0.5	1.5	1.7	2.2	2.5	2.4
Refined Production	5340.8	5419.8	5594.0	5716.3	5701.1	5780.1	5877.5	5998.0	6139.6	6237.0
% Change	3.0	1.5	3.2	2.2	-0.3	1.4	1.7	2.1	2.4	1.6
Inventory Level	528.2	590.1	649.4	704.2	627.0	574.7	521.5	504.2	488.3	473.3
Months Consumption	1.20	1.31	1.40	1.49	1.30	1.19	1.06	1.02	0.96	0.92
LME Price, c/lb	50.8	43.2	53.5	56.6	68.4	74.0	79.4	84.3	88.7	93.3
% Change	-26.3	-14.8	23.7	5.9	20.9	8.2	7.2	6.2	5.3	5.1
Real Price, 1990 c/lb	49.6	40.7	48.5	49.4	57.5	59.8	61.7	63.0	63.7	64.4

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UNITED STATES CONSUMPTION BY END USE

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Galvanize	465.0	380.0	450.0	465.0	480.0	529.0	550.0	559.0	583.0	545.0
% Change	9.4	-18.3	18.4	3.3	3.2	10.2	4.0	1.6	4.3	-6.5
Diecast	209.8	208.4	216.8	228.4	214.0	230.7	229.0	263.0	220.0	209.0
% Change	-3.7	-0.7	4.0	5.4	-6.3	7.8	-0.7	14.8	-16.3	-5.0
Brass	158.2	117.6	138.2	161.6	131.0	135.0	139.0	146.0	130.0	120.0
% Change	8.2	-25.7	17.5	16.9	-18.9	3.1	3.0	5.0	-11.0	-7.7
Other Uses	102.2	94.6	129.0	125.0	137.0	104.3	134.0	121.0	127.0	123.0
% Change	13.6	-7.4	36.4	-3.1	9.6	-23.9	28.5	-9.7	5.0	-3.1
Total Consumption	935.2	800.6	934.0	980.0	962.0	999.0	1052.0	1089.0	1059.0	997.0
% Change	6.4	-14.4	16.7	4.9	-1.8	3.8	5.3	3.5	-2.8	-5.9

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Galvanize	519.2	544.9	550.7	586.6	597.6	603.7	609.9	616.1	622.5	629.0
% Change	-4.7	5.0	1.1	6.5	1.9	1.0	1.0	1.0	1.0	1.0
Diecast	206.0	214.8	210.6	214.6	205.6	206.7	202.8	199.1	195.4	191.8
% Change	-1.4	4.3	-1.9	1.9	-4.2	0.5	-1.9	-1.8	-1.8	-1.8
Brass	113.7	113.7	108.8	118.8	118.9	119.0	119.1	119.1	119.2	119.4
% Change	-5.3	0.0	-4.4	9.2	0.1	0.1	0.1	0.1	0.1	0.1
Other Uses	111.0	89.5	119.9	99.0	106.8	74.4	66.6	60.3	70.7	77.9
% Change	-9.7	-19.4	33.9	-17.4	7.8	-30.3	-10.5	-9.4	17.2	10.1
Total Consumption	949.9	962.9	990.0	1019.1	1028.9	1003.8	998.4	994.7	1007.9	1018.0
% Change	-4.7	1.4	2.8	2.9	1.0	-2.4	-0.5	-0.4	1.3	1.0

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REFINED ZINC CONSUMPTION BY REGION

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
United States	935.2	800.6	934.0	980.0	962.0	999.0	1052.0	1089.0	1059.0	997.0
% Change	6.4	-14.4	16.7	4.9	-1.8	3.8	5.3	3.5	-2.8	-5.9
Canada	140.0	120.0	144.0	146.0	156.0	155.0	158.0	159.0	148.0	126.0
% Change	5.3	-14.3	20.0	1.4	6.8	-0.6	1.9	0.6	-6.9	-14.9
Europe	1611.0	1563.0	1645.0	1683.0	1665.0	1703.0	1733.0	1854.0	1846.0	1912.0
% Change	-7.0	-3.0	5.2	2.3	-1.1	2.3	1.8	7.0	-0.4	3.6
Japan	699.1	703.0	771.0	774.0	780.0	753.0	729.0	774.0	769.0	814.0
% Change	-7.0	0.6	9.7	0.4	0.8	-3.5	-3.2	6.2	-0.6	5.9
S. Korea	78.5	94.4	113.2	123.0	125.0	154.0	179.0	173.0	196.0	227.0
% Change	15.4	20.3	19.9	8.7	1.6	23.2	16.2	-3.4	13.3	15.8
Other Countries	958.2	955.0	948.8	998.0	1057.0	1126.0	1196.0	1237.0	1213.0	1205.0
% Change	3.5	-0.3	-0.6	5.2	5.9	6.5	6.2	3.4	-1.9	-0.7
Non-Socialist World	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
% Change	-1.5	-4.2	7.6	3.2	0.9	3.1	3.2	4.7	-1.0	1.0

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	949.9	962.9	990.0	1019.1	1028.9	1003.8	998.4	994.7	1007.9	1018.0
% Change	-4.7	1.4	2.8	2.9	1.0	-2.4	-0.5	-0.4	1.3	1.0
Canada	125.5	129.3	133.1	139.1	141.1	143.3	145.6	148.0	150.5	153.1
% Change	-0.4	3.0	3.0	4.5	1.5	1.5	1.6	1.6	1.7	1.7
Europe	1915.1	1958.6	1996.0	2009.0	2052.5	2078.4	2098.1	2098.5	2126.8	2152.6
% Change	0.2	2.3	1.9	0.7	2.2	1.3	0.9	0.0	1.3	1.2
Japan	850.1	872.9	899.6	894.7	903.8	890.0	904.8	921.5	951.9	942.3
% Change	4.4	2.7	3.1	-0.6	1.0	-1.5	1.7	1.8	3.3	-1.0
S. Korea	255.2	266.6	278.4	290.5	304.9	310.7	316.9	323.5	330.5	337.9
% Change	12.4	4.5	4.4	4.3	5.0	1.9	2.0	2.1	2.2	2.2
Other Countries	1188.5	1227.5	1267.7	1309.2	1347.0	1386.3	1426.9	1469.1	1507.8	1548.1
% Change	-1.4	3.3	3.3	3.3	2.9	2.9	2.9	3.0	2.6	2.7
Non-Socialist World	5284.3	5417.8	5564.8	5661.4	5778.3	5812.4	5890.7	5955.3	6075.5	6152.0
% Change	0.1	2.5	2.7	1.7	2.1	0.6	1.3	1.1	2.0	1.3

10 Year Annual Average % Growth Rates Period Ending

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	0.2	1.9	0.6	0.4	0.7	0.0	-0.5	-0.9	-0.5	0.2
Canada	-1.1	0.7	-0.8	-0.5	-1.0	-0.8	-0.8	-0.7	0.2	2.0
Japan	1.7	2.3	2.0	1.8	2.1	2.0	1.9	1.2	1.4	1.2
Europe	2.0	2.2	1.6	1.5	1.5	1.7	2.2	1.8	2.2	1.5
South Korea	12.5	10.9	9.4	9.0	9.3	7.3	5.9	6.5	5.4	4.1
Other Countries	2.2	2.5	2.9	2.8	2.5	2.1	1.8	1.7	2.2	2.5
World Total	1.8	2.5	2.0	1.9	2.0	1.7	1.6	1.2	1.5	1.5

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ZINC MINE AND REFINED PRODUCTION

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Mine Capacity	5437.0	5588.0	5493.0	5604.0	5584.0	5626.0	5645.0	5668.0	5715.0	5879.0
Operating Rate	82.0	86.0	87.8	91.0	92.3	88.5	91.2	90.3	91.6	91.0
Mine Production	4459.0	4804.0	4823.0	5100.0	5152.0	4978.0	5149.0	5120.0	5237.0	5350.0
% Change	-1.2	7.7	0.4	5.7	1.0	-3.4	3.4	-0.6	2.3	2.2
- CPE Net Imp Ore/Conc	107.0	119.0	164.0	176.0	137.0	101.0	103.0	75.0	50.0	42.0
- Direct Use of Oxide	70.0	50.0	50.0	64.0	69.0	30.0	15.0	5.0	4.0	4.0
= Primary Refined Prod	4266.0	3993.0	4260.0	4559.0	4672.0	4560.0	4765.0	4941.0	4907.0	4849.0
+ Secondary Production	276.0	325.0	352.0	333.0	324.0	295.0	293.0	299.0	310.0	334.0
= Total Refined Prod	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
% Change	1.8	-4.9	6.8	6.1	2.1	-2.8	4.2	3.6	-0.4	-0.7

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Mine Capacity	6067.0	6123.0	6366.0	6472.0	6472.0	6497.0	6561.8	6656.9	6807.1	6950.3
Operating Rate	88.6	88.2	87.4	87.7	87.3	88.3	88.9	89.5	89.7	90.0
Mine Production	5374.6	5400.0	5565.7	5678.6	5647.4	5733.9	5830.7	5958.4	6109.3	6256.5
% Change	0.5	0.5	3.1	2.0	-0.5	1.5	1.7	2.2	2.5	2.4
- CPE Net Imp Ore/Conc	0.0	0.0	0.0	0.0	0.0	40.0	60.0	80.0	120.0	150.0
- Direct Use of Oxide	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
= Primary Refined Prod	5008.1	5072.0	5227.8	5333.9	5304.6	5370.9	5456.9	5566.9	5698.8	5787.2
+ Secondary Production	332.7	347.8	366.2	382.3	396.5	409.2	420.7	431.1	440.8	449.8
= Total Refined Prod	5340.8	5419.8	5594.0	5716.3	5701.1	5780.1	5877.5	5998.0	6139.6	6237.0
% Change	3.0	1.5	3.2	2.2	-0.3	1.4	1.7	2.1	2.4	1.6

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ZINC MARKET BALANCE & INVENTORIES

(000 Tonnes)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Refined Consumption	4422.0	4236.0	4556.0	4704.0	4745.0	4890.0	5047.0	5286.0	5231.0	5281.0
Refined Production	4542.0	4318.0	4612.0	4892.0	4996.0	4855.0	5058.0	5240.0	5217.0	5183.0
CPE Net Imports Metal	64.0	154.0	238.0	245.0	249.0	45.0	-13.0	43.0	42.0	-39.0
Market Balance	90.0	-47.0	-125.0	-53.0	2.0	-80.0	24.0	-89.0	-56.0	-59.0
Inventory Change	52.0	-43.0	-153.0	7.0	-9.0	10.6	-38.9	-62.2	81.1	-38.9
Unexplained Metal	38.0	-4.0	28.0	-60.0	11.0	-90.6	62.9	-26.8	-137.1	-20.1
Inventory Level	638.0	595.0	442.0	449.0	440.0	450.6	411.7	349.5	430.6	391.7
Months Consumption	1.73	1.69	1.16	1.15	1.11	1.11	0.98	0.79	0.99	0.89

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Refined Consumption	5284.3	5417.8	5564.8	5661.4	5778.3	5812.4	5890.7	5955.3	6075.5	6152.0
Refined Production	5340.8	5419.8	5594.0	5716.3	5701.1	5780.1	5877.5	5998.0	6139.6	6237.0
CPE Net Imports Metal	-80.0	-60.0	-30.0	0.0	0.0	20.0	40.0	60.0	80.0	100.0
Market Balance	136.5	61.9	59.3	54.8	-77.2	-52.4	-53.2	-17.3	-15.9	-15.1
Inventory Change	136.5	61.9	59.3	54.8	-77.2	-52.4	-53.2	-17.3	-15.9	-15.1
Unexplained Metal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inventory Level	528.2	590.1	649.4	704.2	627.0	574.7	521.5	504.2	488.3	473.3
Months Consumption	1.20	1.31	1.40	1.49	1.30	1.19	1.06	1.02	0.96	0.92

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WORLD ZINC MARKET PRICES AND COST TRENDS

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
LME Price, cents/lb	38.9	33.7	34.7	40.5	36.2	34.3	36.2	56.3	77.6	68.8
% Change	12.9	-13.4	3.0	16.5	-10.4	-5.2	5.4	55.4	38.0	-11.3
US Producer Price, c/lb	44.5	38.5	41.4	48.6	40.4	38.0	41.9	60.2	82.0	74.6
% Change	19.0	-13.6	7.6	17.4	-16.9	-5.9	10.3	43.6	36.3	-9.1
LME Price, 1990 c/lb	48.3	40.2	40.7	46.5	41.3	39.7	40.9	62.1	81.5	68.8
LME Price, Stg/tonne	426.7	425.6	505.1	669.6	614.9	516.0	487.8	696.8	1045.2	854.3
% Change	30.6	-0.3	18.7	32.6	-8.2	-16.1	-5.5	42.8	50.0	-18.3
Cost Indicators:										
Floor, Swing Facilities	32.8	33.1	33.6	34.0	34.0	35.4	36.8	38.2	39.8	45.0
Target, New Facilities	42.8	43.3	44.4	45.7	47.0	48.9	50.8	52.9	55.0	62.2

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
LME Price, cents/lb	50.8	43.2	53.5	56.6	68.4	74.0	79.4	84.3	88.7	93.3
% Change	-26.3	-14.8	23.7	5.9	20.9	8.2	7.2	6.2	5.3	5.1
US Producer Price, c/lb	52.4	47.1	58.1	61.2	72.7	78.2	83.4	88.2	92.6	97.0
% Change	-29.8	-10.0	23.3	5.3	18.9	7.6	6.6	5.8	4.9	4.8
LME Price, 1990 c/lb	49.6	40.7	48.5	49.4	57.5	59.8	61.7	63.0	63.7	64.4
LME Price, Stg/tonne	649.9	549.0	654.1	681.3	844.5	930.1	1014.4	1095.9	1173.0	1233.5
% Change	-23.9	-15.5	19.2	4.2	24.0	10.1	9.1	8.0	7.0	5.1
Cost Indicators:										
Floor, Swing Facilities	51.1	49.0	54.6	56.8	59.1	61.5	63.9	66.5	69.1	71.9
Target, New Facilities	68.0	66.0	72.1	75.0	78.0	81.1	84.4	87.8	91.3	94.9

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APPENDIX F

Base Case Copper Market Forecast Tables

WORLD COPPER FORECAST SUMMARY

	1984	1985	1986	1987	1988	1989
Consumption	7667.9	7328.7	7674.2	8012.3	8211.1	8638.9
% Change	12.1	-4.4	4.7	4.4	2.5	5.2
Mine Capacity	7347.0	7154.0	7178.0	7285.0	7586.0	7945.0
Operating Rate	86.7	89.9	89.7	91.8	88.5	89.9
Mine Production	6369.2	6432.5	6440.7	6690.9	6715.9	7139.7
% Change	1.5	1.0	0.1	3.9	0.4	6.3
Refined Production	7185.5	7316.9	7433.5	7631.3	7973.6	8386.0
% Change	-1.8	1.8	1.6	2.7	4.5	5.2
Inventory Level	1219.7	1073.9	892.8	521.6	585.1	664.9
Months Consumption	1.91	1.76	1.40	0.78	0.86	0.92
LME HG Price, c/lb	62.5	64.9	62.1	80.1	117.9	128.9
% Change	-13.3	3.7	-4.3	29.0	47.2	9.3
Real HG Price, 1990 c/lb	76.3	76.9	71.7	89.6	127.7	134.2

	1990	1991	1992	1993	1994	1995
Consumption	8749.6	8643.2	8864.2	9174.7	9425.9	9665.1
% Change	1.3	-1.2	2.6	3.5	2.7	2.5
Mine Capacity	8087.0	8412.0	8599.0	8858.0	9101.0	9547.9
Operating Rate	89.2	86.6	87.4	88.6	89.2	89.9
Mine Production	7217.6	7280.8	7512.2	7849.9	8119.6	8581.5
% Change	1.1	0.9	3.2	4.5	3.4	5.7
Refined Production	8459.6	8475.9	8709.6	9102.7	9422.1	9879.7
% Change	0.9	0.2	2.8	4.5	3.5	4.9
Inventory Level	709.2	791.9	712.4	690.4	686.5	901.1
Months Consumption	0.97	1.10	0.96	0.90	0.87	1.12
LME HG Price, c/lb	120.7	106.8	94.7	112.7	126.6	113.7
% Change	-6.4	-11.5	-11.3	18.9	12.3	-10.2
Real HG Price, 1990 c/lb	120.7	102.5	88.2	101.6	110.3	95.3

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REFINED COPPER CONSUMPTION BY REGION

(000 Tonnes)

	1984	1985	1986	1987	1988	1989
United States	2122.7	1958.0	2100.0	2126.7	2205.9	2203.5
% Change	17.7	-7.8	7.3	1.3	3.7	-0.1
Canada	231.0	222.5	225.6	232.3	236.3	218.6
% Change	18.5	-3.7	1.4	3.0	1.7	-7.5
Europe	2765.8	2734.3	2764.2	2802.8	2870.1	3064.7
% Change	6.0	-1.1	1.1	1.4	2.4	6.8
Japan	1368.3	1226.3	1210.5	1276.6	1330.7	1446.6
% Change	12.5	-10.4	-1.3	5.5	4.2	8.7
S. Korea	188.0	206.6	262.3	259.0	266.3	248.5
% Change	23.4	9.9	27.0	-1.3	2.8	-6.7
Taiwan	136.9	92.4	156.0	207.8	214.9	315.3
% Change	30.6	-32.5	68.8	33.2	3.4	46.7
Other Countries	855.2	888.6	955.6	1107.1	1086.9	1141.7
% Change	12.4	3.9	7.5	15.9	-1.8	5.0
Non-Socialist World	7667.9	7328.7	7674.2	8012.3	8211.1	8638.9
% Change	12.1	-4.4	4.7	4.4	2.5	5.2

	1990	1991	1992	1993	1994	1995
United States	2150.4	1980.6	2088.1	2145.8	2184.9	2215.8
% Change	-2.4	-7.9	5.4	2.8	1.8	1.4
Canada	184.4	180.1	182.6	187.8	193.9	192.8
% Change	-15.6	-2.4	1.4	2.8	3.2	-0.6
Europe	3135.0	3116.6	3181.3	3274.5	3352.6	3438.4
% Change	2.3	-0.6	2.1	2.9	2.4	2.6
Japan	1576.5	1585.5	1564.4	1612.2	1643.2	1681.0
% Change	9.0	0.6	-1.3	3.1	1.9	2.3
S. Korea	324.2	334.5	352.2	379.9	414.3	450.5
% Change	30.5	3.2	5.3	7.9	9.0	8.8
Taiwan	264.7	353.8	369.7	400.4	433.7	471.0
% Change	-16.0	33.7	4.5	8.3	8.3	8.6
Other Countries	1114.4	1092.1	1125.8	1174.1	1203.4	1215.6
% Change	-2.4	-2.0	3.1	4.3	2.5	1.0
Non-Socialist World	8749.6	8643.2	8864.2	9174.7	9425.9	9665.1
% Change	1.3	-1.2	2.6	3.5	2.7	2.5

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NSW COPPER MINE AND REFINERY PRODUCTION

(000 Tonnes)

	1984	1985	1986	1987	1988	1989
Mine Capacity	7347.0	7154.0	7178.0	7285.0	7586.0	7945.0
Operating Rate	86.7	89.9	89.7	91.8	88.5	89.9
Mine Production	6369.2	6432.5	6440.7	6690.9	6715.9	7139.7
% Change	1.5	1.0	0.1	3.9	0.4	6.3
Refined Production	7185.5	7316.9	7433.5	7631.3	7973.6	8386.0
% Change	-1.8	1.8	1.6	2.7	4.5	5.2
of which:						
From Primary	6090.5	6082.9	6241.5	6400.0	6554.7	6968.3
% Change	-0.8	-0.1	2.6	2.5	2.4	6.3
From Secondary	1095.0	1234.0	1192.0	1231.3	1418.9	1417.7
% Change	-7.1	12.7	-3.4	3.3	15.2	-0.1

	1990	1991	1992	1993	1994	1995
Mine Capacity	8087.0	8412.0	8599.0	8858.0	9101.0	9547.9
Operating Rate	89.2	86.6	87.4	88.6	89.2	89.9
Mine Production	7217.6	7280.8	7512.2	7849.9	8119.6	8581.5
% Change	1.1	0.9	3.2	4.5	3.4	5.7
Refined Production	8459.6	8475.9	8709.6	9102.7	9422.1	9879.7
% Change	0.9	0.2	2.8	4.5	3.5	4.9
of which:						
From Primary	7001.1	7062.3	7286.9	7614.4	7876.0	8324.0
% Change	0.5	0.9	3.2	4.5	3.4	5.7
From Secondary	1458.5	1413.6	1422.7	1488.3	1546.1	1555.7
% Change	2.9	-3.1	0.6	4.6	3.9	0.6

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COPPER MARKET BALANCE & INVENTORIES

(000 Tonnes)

	1984	1985	1986	1987	1988	1989
Refined Consumption	7667.9	7328.7	7674.2	8012.3	8211.1	8638.9
Refined Production	7185.5	7316.9	7433.5	7631.3	7973.6	8386.0
CPE Net Imports Metal	17.4	79.6	-34.2	-112.6	-151.2	-147.0
Market Balance	-499.8	-91.4	-206.5	-268.4	-86.3	-105.9
Inventory Change	-489.2	-145.8	-181.1	-371.2	63.5	79.8
Unexplained Metal	-10.6	54.4	-25.4	102.8	-149.8	-185.7
Inventory Level	1219.7	1073.9	892.8	521.6	585.1	664.9
Months Consumption	1.91	1.76	1.40	0.78	0.86	0.92

	1990	1991	1992	1993	1994	1995
Refined Consumption	8749.6	8643.2	8864.2	9174.7	9425.9	9665.1
Refined Production	8459.6	8475.9	8709.6	9102.7	9422.1	9879.7
CPE Net Imports Metal	-252.8	-250.0	-75.0	-50.0	0.0	0.0
Market Balance	-37.2	82.7	-79.6	-22.0	-3.9	214.6
Inventory Change	44.3	82.7	-79.6	-22.0	-3.9	214.6
Unexplained Metal	-81.5	0.0	0.0	0.0	0.0	0.0
Inventory Level	709.2	791.9	712.4	690.4	686.5	901.1
Months Consumption	0.97	1.10	0.96	0.90	0.87	1.12

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WORLD COPPER MARKET PRICES AND COST TRENDS

	1984	1985	1986	1987	1988	1989
LME HG Price, cents/lb	62.5	64.9	62.1	80.1	117.9	128.9
% Change	-13.3	3.7	-4.3	29.0	47.2	9.3
Comex 1st Position, c/lb	61.3	61.0	61.6	77.8	114.6	124.9
% Change	-14.7	-0.5	1.1	26.3	47.2	9.0
US Producer Price, c/lb	66.9	67.0	66.1	82.5	120.5	130.9
% Change	-12.6	0.2	-1.4	24.9	46.1	8.7
LME HG Price, 1990 c/lb	76.3	76.9	71.7	89.6	127.7	134.2
LME Price, Stg/tonne	1035.8	1114.1	933.3	1078.9	1460.2	1735.5
% Change	-1.2	7.6	-16.2	15.6	35.3	18.9
LME Price, DM/tonne	3923.0	4209.6	2971.6	3172.1	4563.6	5341.6
% Change	-3.4	7.3	-29.4	6.7	43.9	17.0
LME Price, 000Yen/tonne	327.4	341.1	230.6	255.2	333.0	388.5
% Change	-13.3	4.2	-32.4	10.7	30.5	16.7
Cost Indicators:						
Floor, Swing Facilities	55.2	55.6	53.2	59.0	62.2	60.6
Target, New Facilities	70.6	72.8	68.3	71.1	87.8	84.4

	1990	1991	1992	1993	1994	1995
LME HG Price, cents/lb	120.7	106.8	94.7	112.7	126.6	113.7
% Change	-6.4	-11.5	-11.3	18.9	12.3	-10.2
Comex 1st Position, c/lb	119.1	103.9	92.4	109.4	122.6	110.4
% Change	-4.7	-12.8	-11.0	18.4	12.0	-9.9
US Producer Price, c/lb	123.2	108.6	97.4	114.1	127.1	115.1
% Change	-5.9	-11.8	-10.3	17.2	11.4	-9.4
LME HG Price, 1990 c/lb	120.7	102.5	88.2	101.6	110.3	95.3
LME Price, Stg/tonne	1497.0	1344.7	1200.1	1378.1	1515.9	1370.0
% Change	-13.7	-10.2	-10.8	14.8	10.0	-9.6
LME Price, DM/tonne	4298.3	3953.7	3550.0	4072.2	4462.7	4012.1
% Change	-19.5	-8.0	-10.2	14.7	9.6	-10.1
LME Price, 000Yen/tonne	385.1	321.3	279.9	321.1	351.9	313.2
% Change	-0.9	-16.6	-12.9	14.7	9.6	-11.0
Cost Indicators:						
Floor, Swing Facilities	64.8	66.7	76.0	78.5	82.7	84.1
Target, New Facilities	89.2	91.9	83.0	85.0	89.3	93.8

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APPENDIX G

Base Case Lead Market Forecast Tables

WORLD LEAD FORECAST SUMMARY

	1984	1985	1986	1987	1988	1989
Consumption	3972.0	4026.0	4113.0	4255.0	4362.0	4521.0
% Change	3.8	1.4	2.2	3.5	2.5	3.6
Mine Capacity	2836.0	2787.0	2692.0	2655.0	2656.0	2676.0
Operating Rate	83.7	89.2	84.8	86.7	88.2	85.9
Mine Production	2374.0	2487.0	2282.0	2301.0	2343.0	2299.0
% Change	-3.8	4.8	-8.2	0.8	1.8	-1.9
Refined Production	4059.0	4239.0	4065.0	4257.0	4411.0	4494.0
% Change	3.7	4.4	-4.1	4.7	3.6	1.9
Inventory Level	247.0	302.0	216.6	272.0	264.5	206.3
Months Consumption	0.75	0.90	0.63	0.77	0.73	0.55
LME Price, c/lb	20.2	17.9	18.5	27.1	29.7	30.6
% Change	4.5	-11.3	3.2	46.8	9.7	3.0
Real Price, 1990 c/lb	23.2	20.4	21.3	30.7	32.8	32.2

	1990	1991	1992	1993	1994	1995
Consumption	4535.0	4552.6	4643.0	4750.4	4841.1	4977.0
% Change	0.3	0.4	2.0	2.3	1.9	2.8
Mine Capacity	2739.0	2716.0	2732.0	2790.0	2743.0	2730.9
Operating Rate	86.1	84.4	84.9	85.1	85.5	85.9
Mine Production	2357.0	2293.4	2319.8	2374.2	2345.9	2346.7
% Change	2.5	-2.7	1.2	2.3	-1.2	0.0
Refined Production	4359.0	4526.7	4628.9	4771.3	4824.0	4930.3
% Change	-3.0	3.8	2.3	3.1	1.1	2.2
Inventory Level	253.6	272.6	286.6	314.8	289.4	219.0
Months Consumption	0.67	0.72	0.74	0.80	0.72	0.53
LME Price, c/lb	37.0	27.6	28.7	28.3	31.5	41.2
% Change	20.9	-25.5	4.0	-1.5	11.4	30.6
Real Price, 1990 c/lb	37.0	27.0	27.0	25.6	27.5	34.6

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REFINED LEAD CONSUMPTION BY REGION

(000 Tonnes)

	1984	1985	1986	1987	1988	1989
United States	1134.0	1124.0	1134.0	1217.0	1236.0	1346.0
% Change	-0.9	-0.9	0.9	7.3	1.6	8.9
Canada	122.0	104.0	95.0	109.0	108.0	94.0
% Change	25.8	-14.8	-8.7	14.7	-0.9	-13.0
Japan	391.0	397.0	389.0	378.0	406.0	406.0
% Change	8.9	1.5	-2.0	-2.8	7.4	0.0
Europe	1622.0	1614.0	1661.0	1652.0	1708.0	1736.0
% Change	3.8	-0.5	2.9	-0.5	3.4	1.6
Other Countries	703.0	787.0	834.0	899.0	904.0	939.0
% Change	6.2	11.9	6.0	7.8	0.6	3.9
Non-Socialist World	3972.0	4026.0	4113.0	4255.0	4362.0	4521.0
% Change	3.8	1.4	2.2	3.5	2.5	3.6

	1990	1991	1992	1993	1994	1995
United States	1316.0	1296.6	1317.0	1346.3	1374.3	1410.8
% Change	-2.2	-1.5	1.6	2.2	2.1	2.7
Canada	91.0	85.2	87.8	89.8	93.3	95.3
% Change	-3.2	-6.4	3.1	2.2	4.0	2.1
Japan	417.0	420.1	429.1	441.9	452.1	461.9
% Change	2.7	0.7	2.2	3.0	2.3	2.2
Europe	1764.0	1766.0	1767.0	1768.8	1759.0	1792.0
% Change	1.6	0.1	0.1	0.1	-0.6	1.9
Other Countries	947.0	984.9	1042.1	1103.6	1162.4	1216.9
% Change	0.9	4.0	5.8	5.9	5.3	4.7
Non-Socialist World	4535.0	4552.6	4643.0	4750.4	4841.1	4977.0
% Change	0.3	0.4	2.0	2.3	1.9	2.8

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LEAD MINE AND REFINERY PRODUCTION

(000 Tonnes)

	1984	1985	1986	1987	1988	1989
Mine Capacity	2836.0	2787.0	2692.0	2655.0	2656.0	2676.0
Operating Rate	83.7	89.2	84.8	86.7	88.2	85.9
Mine Production	2374.0	2487.0	2282.0	2301.0	2343.0	2299.0
% Change	-3.8	4.8	-8.2	0.8	1.8	-1.9
- CPE Net Imp Ore/Conc	58.0	64.0	44.0	-12.0	-9.0	7.0
+ CPE Net Exp Bullion	18.0	12.0	20.0	26.0	11.0	6.0
+ Secondary Production	1836.0	1835.0	1891.0	2047.0	2112.0	2289.0
% Change	17.6	-0.1	3.1	8.2	3.2	8.4
= Metal Units Available	4170.0	4270.0	4149.0	4386.0	4475.0	4587.0
Refined Production	4059.0	4239.0	4065.0	4257.0	4411.0	4494.0
% Change	3.7	4.4	-4.1	4.7	3.6	1.9

	1990	1991	1992	1993	1994	1995
Mine Capacity	2739.0	2716.0	2732.0	2790.0	2743.0	2730.9
Operating Rate	86.1	84.4	84.9	85.1	85.5	85.9
Mine Production	2357.0	2293.4	2319.8	2374.2	2345.9	2346.7
% Change	2.5	-2.7	1.2	2.3	-1.2	0.0
- CPE Net Imp Ore/Conc	-8.0	-10.0	-10.0	-10.0	-10.0	-10.0
+ CPE Net Exp Bullion	6.0	6.0	6.0	6.0	6.0	6.0
+ Secondary Production	2279.0	2316.8	2394.8	2485.9	2568.1	2676.0
% Change	-0.4	1.7	3.4	3.8	3.3	4.2
= Metal Units Available	4650.0	4626.1	4730.6	4876.1	4929.9	5038.7
Refined Production	4359.0	4526.7	4628.9	4771.3	4824.0	4930.3
% Change	-3.0	3.8	2.3	3.1	1.1	2.2

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LEAD MARKET BALANCE & INVENTORIES
(000 Tonnes)

	1984	1985	1986	1987	1988	1989
Refined Consumption	3972.0	4026.0	4113.0	4255.0	4362.0	4521.0
CPE Net Imports Metal	88.0	95.0	69.0	14.0	45.0	34.0
Refined Production	4059.0	4239.0	4065.0	4257.0	4411.0	4494.0
Market Balance	-1.0	118.0	-117.0	-12.0	4.0	-61.0
Inventory Change	-111.0	55.0	-85.4	55.4	-7.5	-58.2
Unexplained Metal	110.0	63.0	-31.6	-67.4	11.5	-2.8
Inventory Level	247.0	302.0	216.6	272.0	264.5	206.3
Months Consumption	0.75	0.90	0.63	0.77	0.73	0.55

	1990	1991	1992	1993	1994	1995
Refined Consumption	4535.0	4552.6	4643.0	4750.4	4841.1	4977.0
CPE Net Imports Metal	-80.0	-45.0	-30.0	-10.0	10.0	20.0
Refined Production	4359.0	4526.7	4628.9	4771.3	4824.0	4930.3
Market Balance	-96.0	19.0	15.9	30.9	-27.2	-66.6
Inventory Change	47.3	19.0	14.0	28.2	-25.4	-70.4
Unexplained Metal	-143.3	0.0	1.9	2.8	-1.8	3.7
Inventory Level	253.6	272.6	286.6	314.8	289.4	219.0
Months Consumption	0.67	0.72	0.74	0.80	0.72	0.53

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WORLD LEAD MARKET PRICES AND COST TRENDS

	1984	1985	1986	1987	1988	1989
LME Price, cents/lb	20.2	17.9	18.5	27.1	29.7	30.6
% Change	17.9	-25.4	15.4	63.3	3.3	6.0
US Producer Price, c/lb	25.5	19.1	22.0	35.9	37.1	39.3
% Change	17.9	-25.4	15.4	63.3	3.3	6.0
LME Price, 1990 c/lb	23.2	20.4	21.3	30.7	32.8	32.2
LME Price, Stg/tonne	333.6	303.4	277.4	365.1	368.2	412.4
% Change	19.0	-9.0	-8.6	31.6	0.8	12.0
Cost Indicators:						
Floor, Swing Facilities	17.5	18.1	18.5	19.1	19.7	20.3
Target, New Facilities	25.7	26.7	27.5	27.6	28.4	29.3

	1990	1991	1992	1993	1994	1995
LME Price, cents/lb	37.0	27.6	28.7	28.3	31.5	41.2
% Change	17.0	-29.8	2.9	-1.1	11.4	25.2
US Producer Price, c/lb	46.0	32.3	33.2	32.9	36.6	45.8
% Change	17.0	-29.8	2.9	-1.1	11.4	25.2
LME Price, 1990 c/lb	37.0	27.0	27.0	25.6	27.5	34.6
LME Price, Stg/tonne	459.7	353.4	364.4	346.0	379.2	508.1
% Change	11.5	-23.1	3.1	-5.1	9.6	34.0
Cost Indicators:						
Floor, Swing Facilities	20.9	21.5	22.1	22.8	23.5	24.2
Target, New Facilities	30.1	31.0	32.0	32.9	33.9	34.9

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